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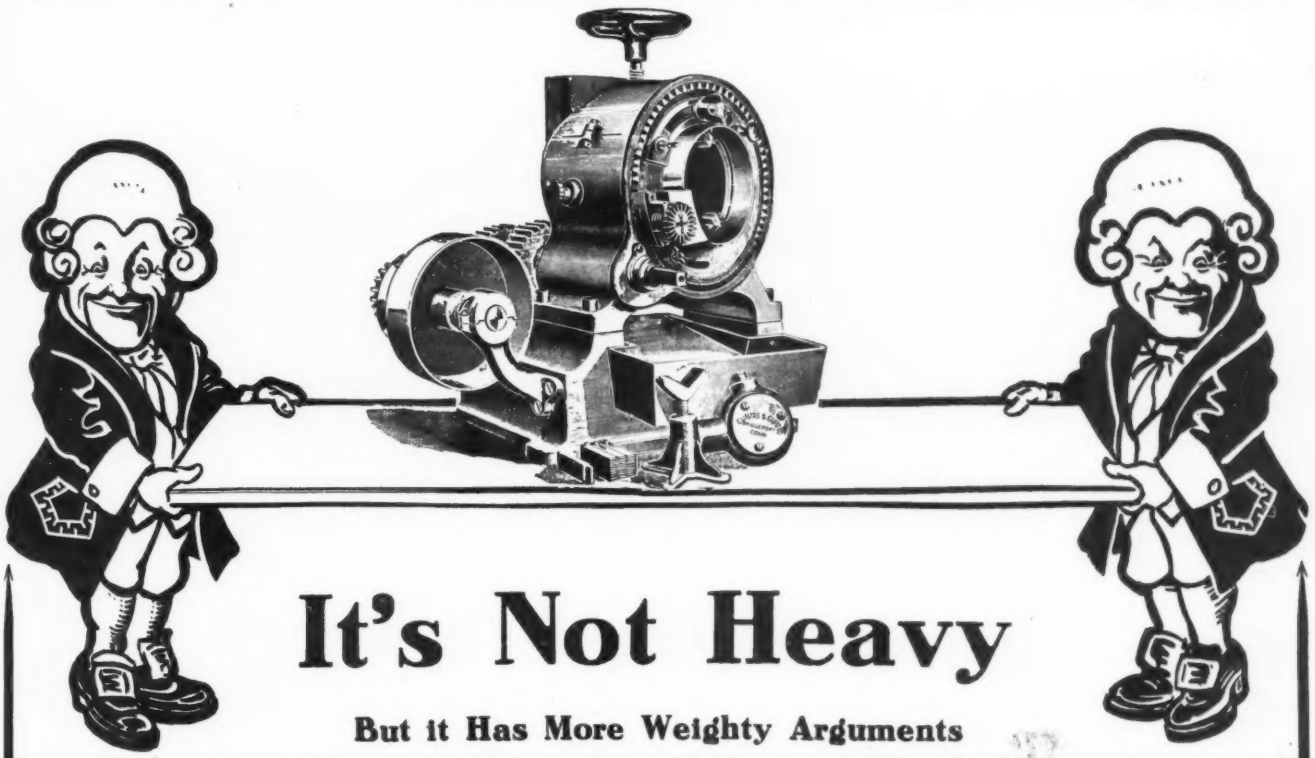

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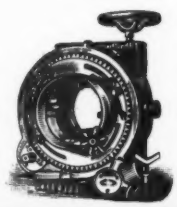

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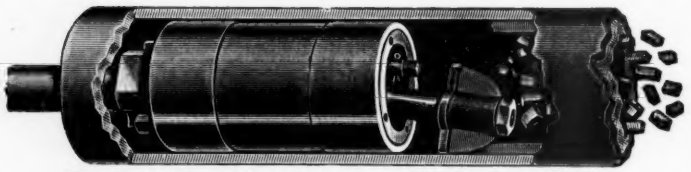

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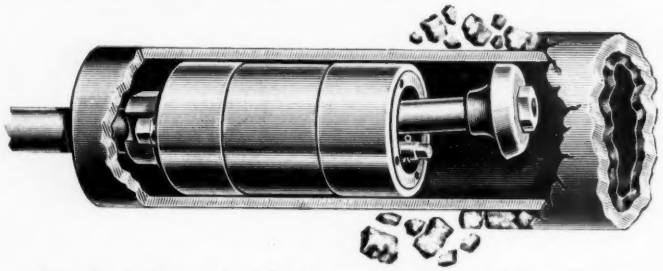

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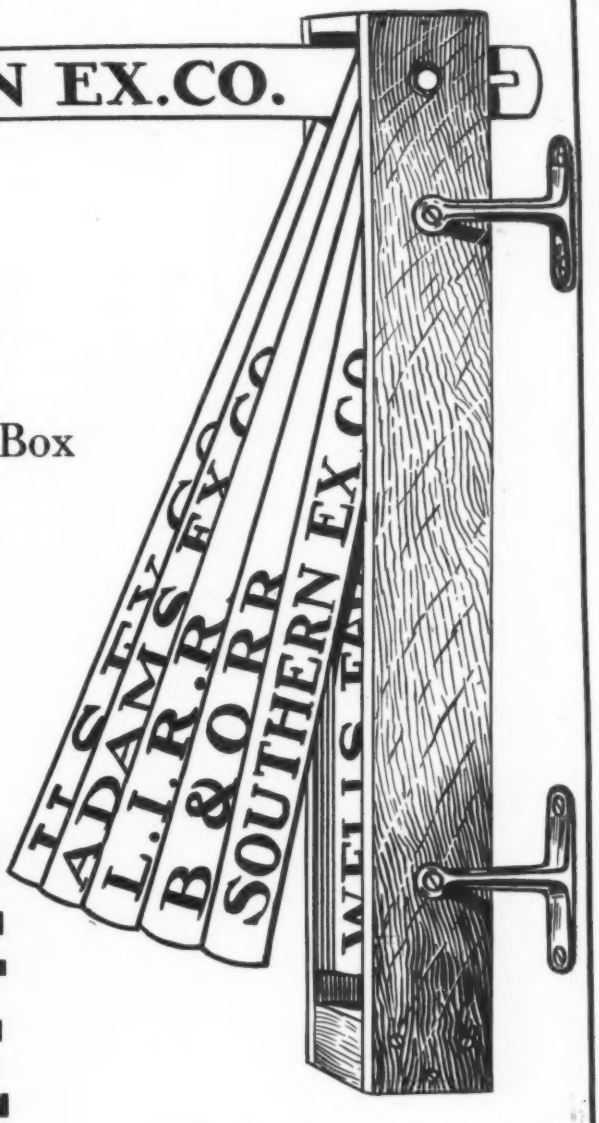

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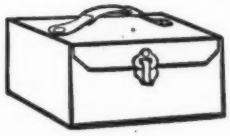

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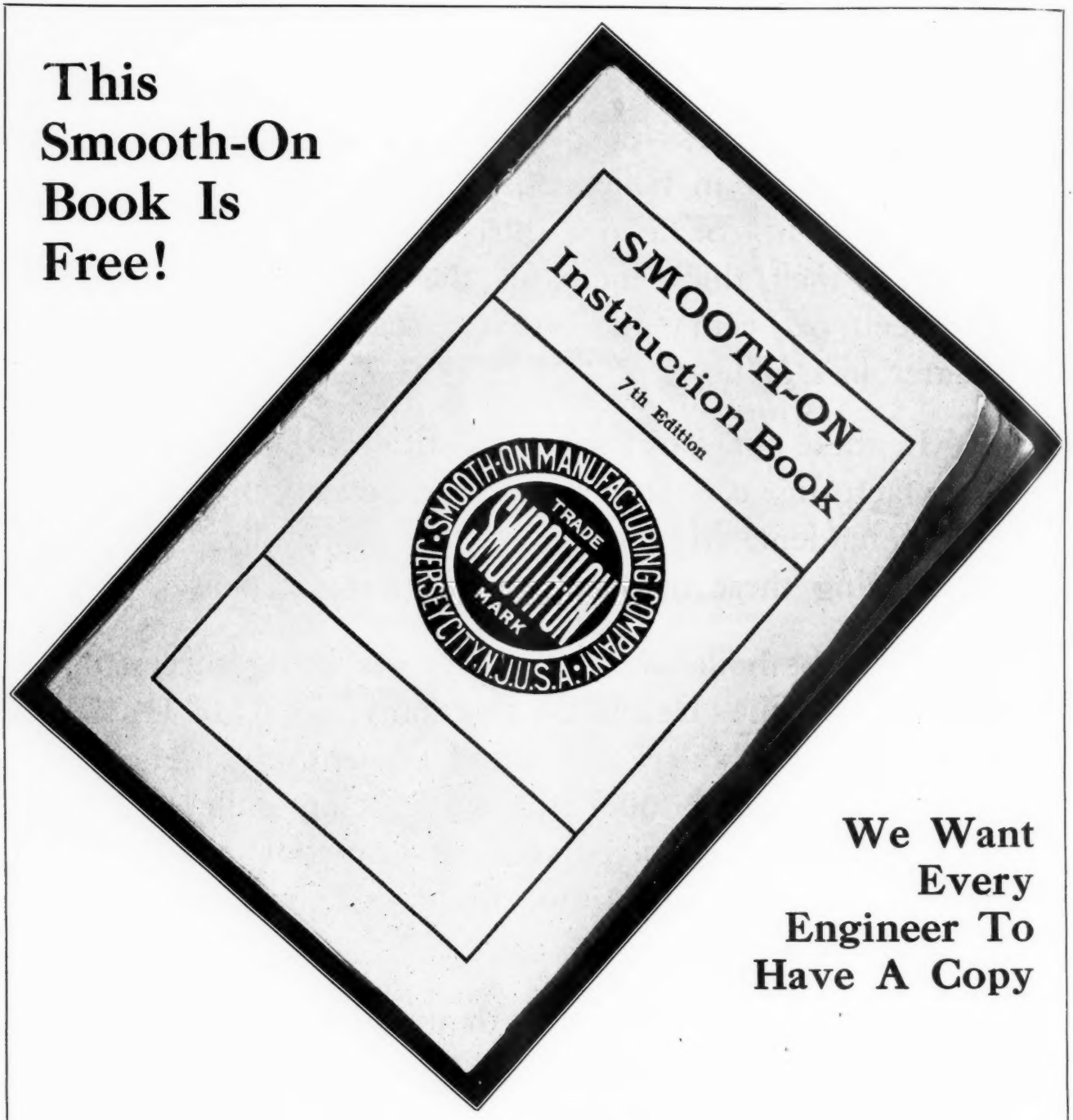

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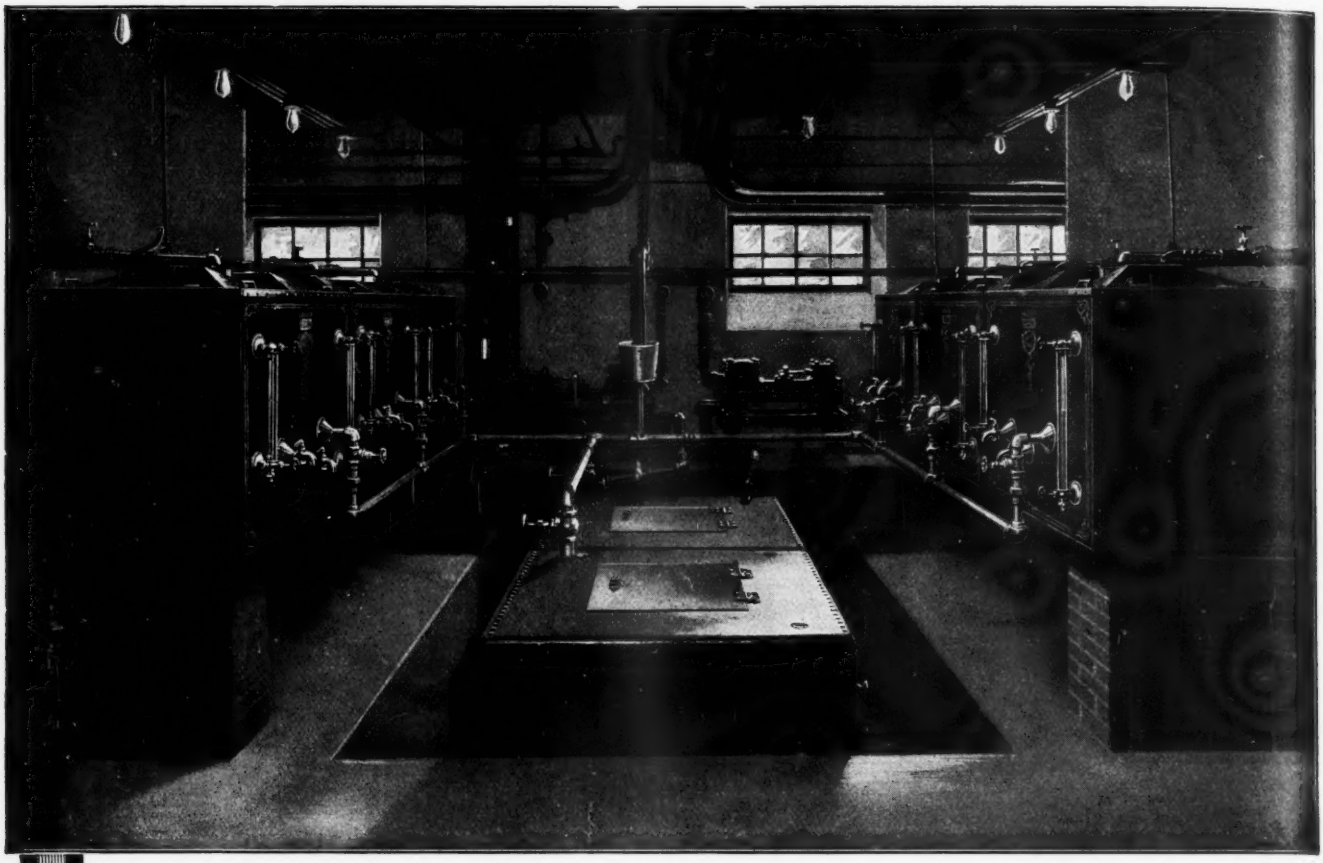

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English Practice in Coal Handling Plants

General Outline of the Methods Employed in Great Britain for Handling Coal, with Descriptions of Certain Ingenious Devices

BY JAMES A. SEAGER

The evolution of large power stations for the supply of electricity has opened the eyes of British engineers to the importance of properly handling the raw material of this industry. When it is remembered that the problems of transportation of material in an electric-power station are reduced to the utmost simplicity as compared with factories established, say, for flour milling, sugar refining or chemical industries, there is some excuse for the fact that until comparatively recent years the mechanical handling of material obtained among engineers designing power houses an attention completely subsidiary to the proper construction of efficient engines and reliable electrical machinery. The passage of electricity requires but an insulated copper cable; steam is supplied from the boilers to the engines by means of a permanent steam pipe, the design of which ends with proper capacity, strength and convenient arrangement. The same may be said with regard to the feed-water arrangements, the oil supply, the condensing arrangements, all the materials in this case being fluids, either flowing by gravity or being pumped.

Coal and ash come under another category. They are solids and therefore need special handling. The motion must be imparted to them by the motion of surrounding objects, these being either the parts of automatic machinery or the implements of manual labor, this fact involving special design to meet the requirements of the continual motion of parts which is absent in the cases of fluids and gases. On the adequate and efficient design of such apparatus depend not only such factors in the station welfare as flexibility and economy of handling, but the quality of the coal handled to a large extent depends on the way it was treated in its path from the hopper or truck in which it was received to the boiler; unwise or undue handling has a deteriorating effect upon coal, breaking it up, liberating gas which could be used in combustion, and causing waste due to pulverization.

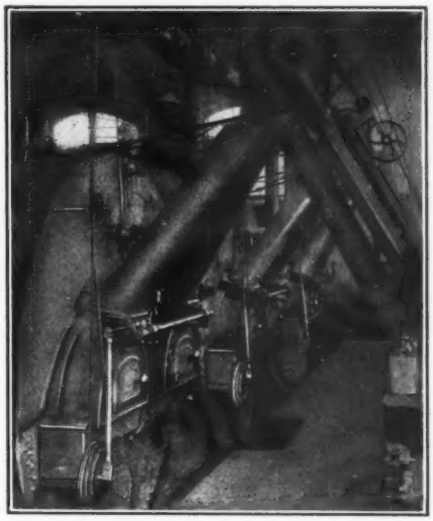


FIG. 1. APPLICATION OF THE "AUTO" STOKER, ASHTON-UNDER-LYNE

Moreover, any dust formed has an unpleasant habit of settling on adjacent surfaces, and not infrequently the pumps for feed water and other gear situated in the boiler house get clogged or their wearing surfaces abraded, if an unwise system of handling be adopted. On the top of all this, it must be remembered that coal is the main item of expense in a station cost sheet; great care is, therefore, taken to secure an accurate account of how it is used, and for this reason, in late years, elaborate and accurate weighing machinery has been installed in power houses for the purpose of registering the amount of coal, either as it is put into the bunkers or onto the fires.

General Outline of English Practice

It is not intended in these notes to give a complete summary of every detail in English practice in coal conveying and weighing, inasmuch as such a description would require considerable space. It is only intended here to give a general outline of practice in this direction shown by English power houses, and to describe briefly one or two of the appliances that have been found most useful.

The system of railroads and waterways in England is so complete that it is only rarely one meets a station in which fuel has to be taken to the station by cart. This principally occurs in the small power houses used in municipal- and urban-district areas of small extent, in which the problems of transport are subordinated to considerations of smoke nuisance and accidental issues. Cases occasionally arise where a power house has been located in

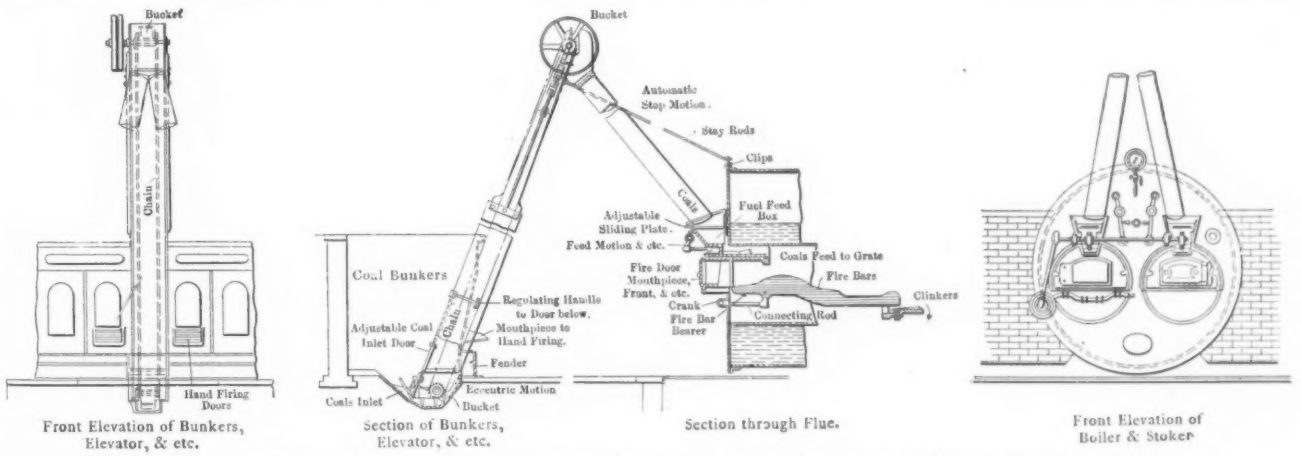


FIG. 2. THE "AUTO" STOKER, ELEVATOR, COAL BUNKERS, ETC., AS APPLIED TO LANCASHIRE OR CORNISH BOILERS

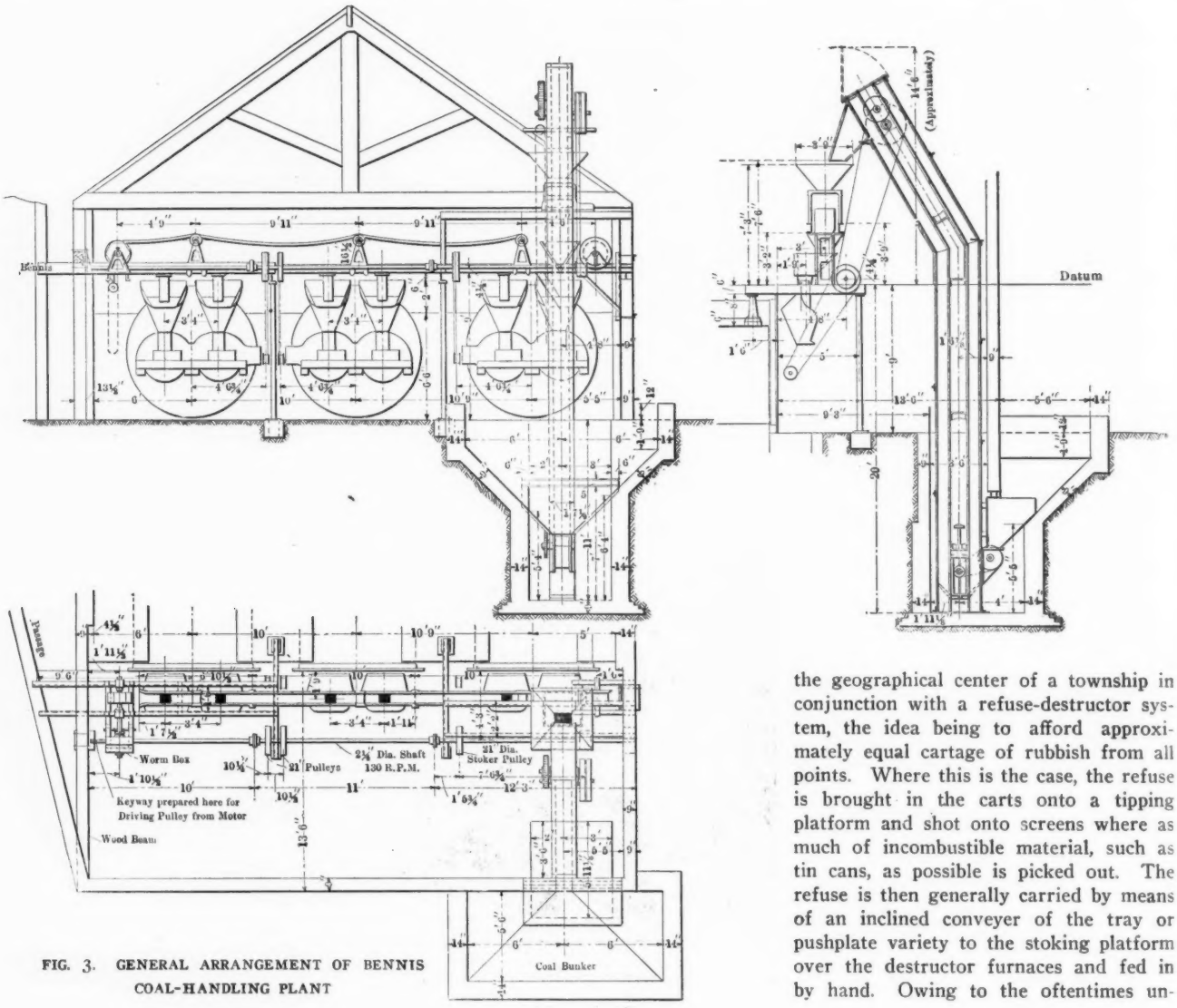


FIG. 3. GENERAL ARRANGEMENT OF BENNIS COAL-HANDLING PLANT

the geographical center of a township in conjunction with a refuse-destructor system, the idea being to afford approximately equal cartage of rubbish from all points. Where this is the case, the refuse is brought in the carts onto a tipping platform and shot onto screens where as much of incombustible material, such as tin cans, as possible is picked out. The refuse is then generally carried by means of an inclined conveyer of the tray or pushplate variety to the stoking platform over the destructor furnaces and fed in by hand. Owing to the oftentimes un-

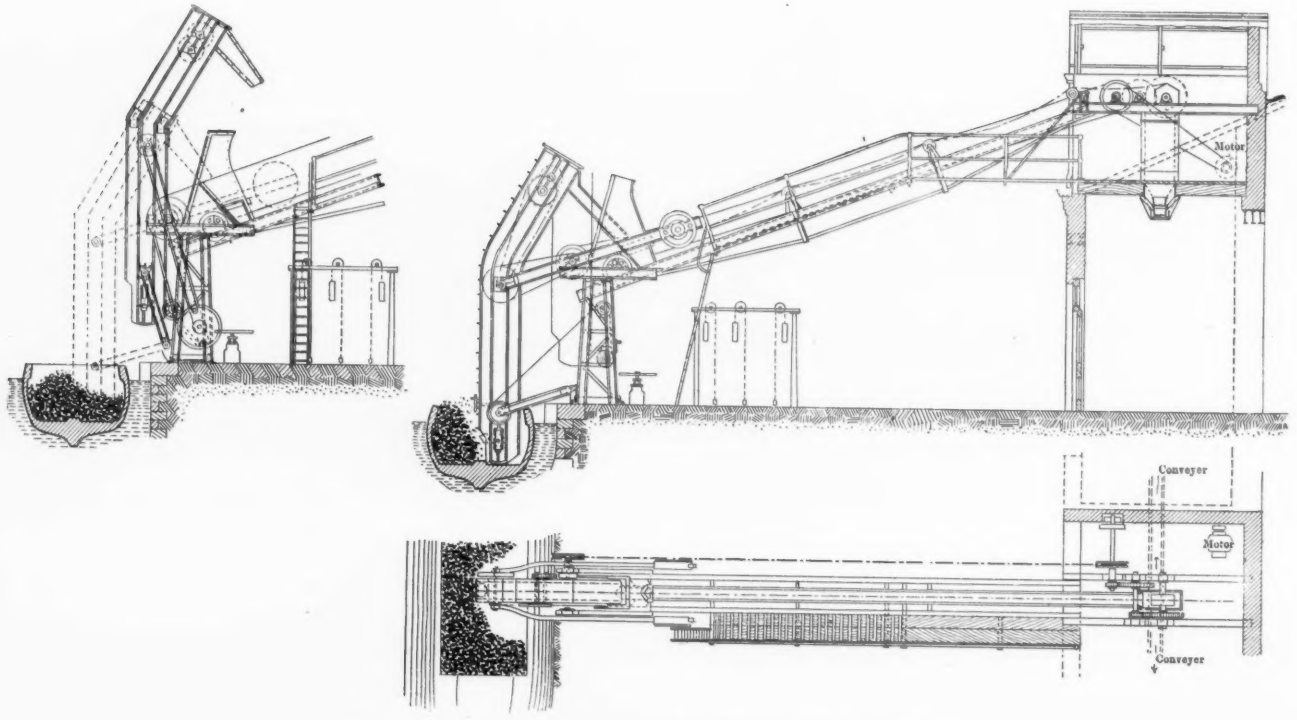


FIG. 4. DETAILS OF INCLINED CONVEYER, COVENTRY CORPORATION

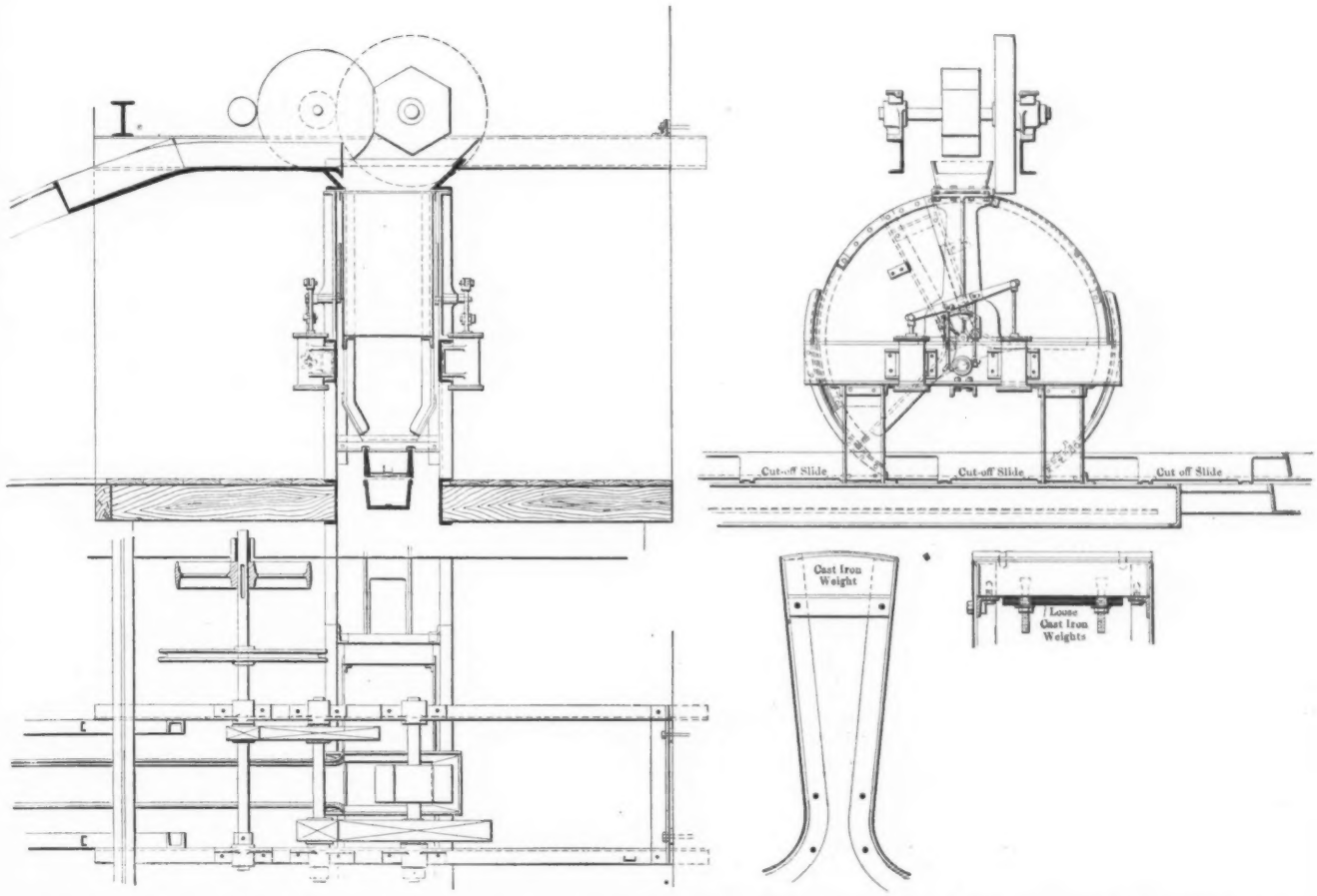


FIG. 5. GENERAL ARRANGEMENT AND DETAILS OF AUTOMATIC WEIGHING MACHINE AND DRIVING GEAR FOR INCLINED CONVEYER

pleasant nature of this fuel no provision is usually made to store it, the problem of variation of supply being generally met by providing auxiliary coal-fired boilers.

In coal-fired stations manual labor is frequently employed to trim the coal from the truck or barge into the coal store or onto the firing floor. In agricultural districts where labor is very cheap and coal dear, owing to freight charges, there is a good deal of reason against installing auxiliary machinery to handle very small capacities of coal and consuming a disproportionate amount of power which is internal loss in the operations of the station. A very curious anomaly, however, obtains in some stations which have adopted the use of automatic stokers with a view to saving labor and obtaining more efficient combustion. These stokers, whether of the sprinkler or coking type, are usually fitted with bins or hoppers into which the coal is placed in bulk, being allowed to trickle through as required by the stoking mechanism. These hoppers are usually placed 5 or 6 feet above the firing floor, and the spectacle is seen of a

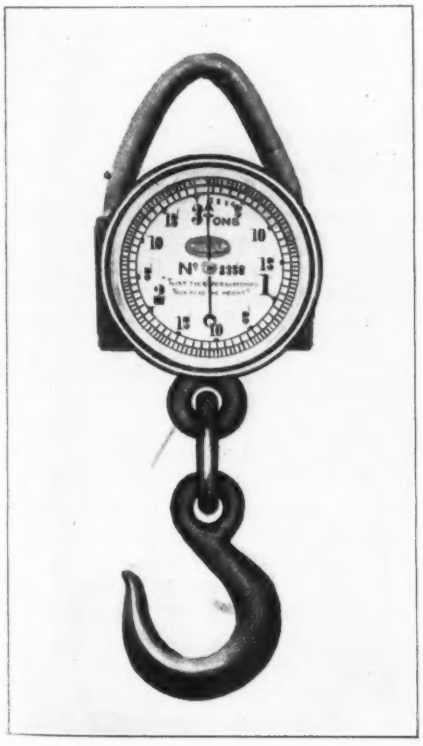


FIG. 6. HYDROSTATIC WEIGHER

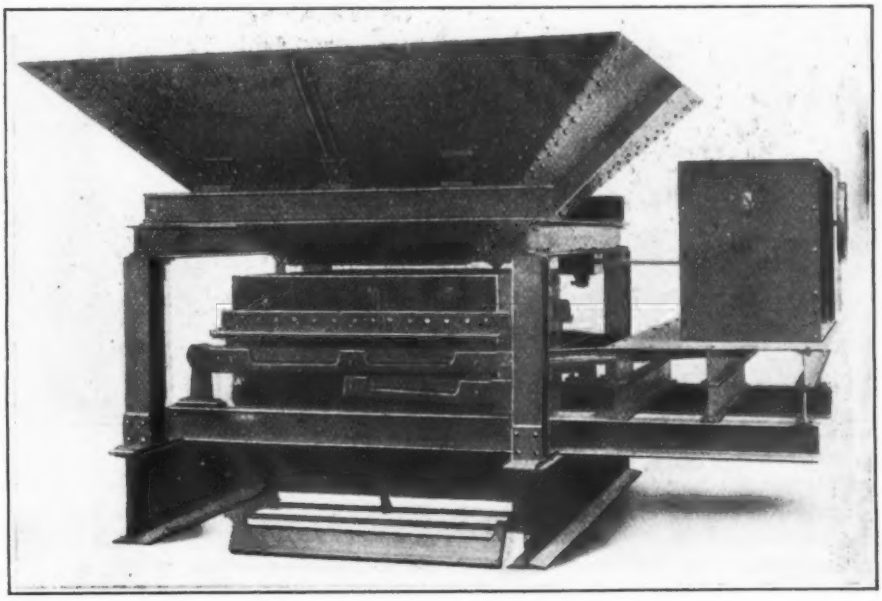


FIG. 7. AVERY AUTOMATIC HOPPER WEIGHER

"navvy" lifting shovelfuls of small coal from a heap on the floor, shoulder or head high, in order to get coal onto the bars, which if lifted direct would require the shovel to be raised as high only as the hips.

Conveyer for Small Stations

This waste of muscular energy is rectified in a neat conveyer contrivance adopted for small stations and made by the Auto-Stoker Company, of Ashton-under-Lyne. Fig. 1 gives a general idea of its appearance, while Fig. 2 is a vertical section of the arrangement. The coal, which is deposited in the first case at the back of the coal to a head above the firing floor, from which it is discharged through spouts into the boiler hoppers. The apparatus is shown fitted to a special form of stoker which this company makes, but it is, of course, applicable to all types of automatic stoker in which a hopper at the front of the boiler is used. Several sets of this type of stoker and elevator were recently supplied to H. M. Office of Works in London. The conveyer gear may be either motor- or steam-driven and effects a considerable saving over hand labor, as the load-inlet door allows of a complete adjustment of the coal lifted to the work which has to be done by the fires.

FIG. 8. APPLICATION OF WEIGHER ON A LARGE SCALE

firing floor in bins having spouts for hand firing, if necessary, and a sufficient width of firing floor for free movement, is allowed to fall through an adjustable coal inlet to a bucket elevator carrying the

As the size of the station increases, two problems begin to develop. The first is the economical handling of fuel, and the second is the measurement of its weight. As distances and hights increase, the possibility of using a wheelbarrow and a laborer diminishes, and as cubic measurements of coal used per day go up, it becomes more and more cumbersome to weight it out on the firing floor, and the interests involved are far too large to depend upon railway weights. In stations of 500 kilowatts capacity and upward, mechanical appliances for unloading, conveying, storing, elevating, distributing and stoking become more and more necessary, and modern practice in Great Britain presents some very fine examples of such work. In some cases where the natural contour of the land permits, as the Carville generating station of the Newcastle-upon-Tyne Electric Supply Company, Ltd., and the central station of the Sheffield Corporation Electricity Department at Neepsend, advantage is taken of the low level of the works with relation to railway sidings in order to run the coal in trucks onto an elevated railroad supported on trestles, on which turnouts are provided leading into the ends of the boiler houses, the coal feeding itself thence by gravity onto the furnaces below. In other cases where the ground does not permit of this simple arrangement the coal is elevated by bucket conveyers to sets of bunkers above the boilers from the ground level.

Typical Coal-handling Gear

It is not often, however, that the small and medium-sized station can go to the expense of such extensive arrangements, and Fig. 3 shows a typical arrangement of coal-handling gear for small English stations, supplied by E. Bennis & Co., Ltd., of Bolton. The coal, brought into the works by truck or cart, is tipped into the receiving hopper or coal bunker at the side of the building and is elevated to a hight by means of a main bucket elevator inclosed, for the sake of dust prevention, in two parallel sheet-steel rectangular cases. From the head of this elevator the coal is tipped into an automatic weighing machine which thus registers the total coal brought to the furnaces. The outlet of the weigher feeds onto a steel-chain conveyer running in a shallow trough which has openings admitting to chutes for each boiler. The system is motor-operated, and is capable of dealing with 10 tons of coal per hour. This illustrates a very useful type of conveyer gear in small stations where the total electrical output is so small as to render the continuous weighing of coal supplied to each boiler an unnecessary complication.

Another interesting example of coal-handling plant erected within recent years by the same firm is the installation of the municipal electric-generating station at Coventry. Here the coal for feeding six Lancashire boilers is brought to the station by barge, and it is lifted at the rate of 20 tons per hour by a Bennis bucket-type elevator carried by a pantograph arrangement, so that, when not in use,

the elevator may be folded in beyond the edge of the wharf. Fig. 4 shows the arrangement of this gear, and it will be seen that as the pressed-steel buckets of the elevator come into actual contact with the coal in the barge no hopper or boot is necessary. The position of the elevator is capable of adjustment while in operation in order to get at various parts of the barge load. The power taken by the elevator is provided by a 4-brake horsepower motor, though the average consumption is only about 3 brake horsepower for 20 tons per hour.

Automatic Weighing Machine

Fig. 5 shows the automatic weighing machine used on this installation, consisting of a semicircular box, about 2 feet in width, carried on steel trunnions fixed in sensitive bearings. The box is about 6 feet in diameter and is divided into six compartments by means of a division plate of sufficient weight to counterbalance a load of 5 hundredweight. The machine works on an oscillating principle. Coal is discharged from the conveyer into the compartment which is on the opposite side of the center line of the arrangement to that on which the weight of the division plate acts. Consequently, when the 5-hundredweight charge of coal has been discharged into the compartment the apparatus rocks over and empties the contents into the conveyer below, which takes the coal away to the boilers. As the compartment rises, the opening caused by the falling of the hopper is closed, thus rendering the compartment ready to receive another discharge of coal. The momentum of the rocking motion is taken up by an ingenious device on the principle of an air buffer, and each oscillation is indicated on an automatic counter, thus registering the number of 5 hundredweights weighed.

The question of weighing the coal has received very careful attention in English practice. In one large London station, for example, where the coal bunkers are situated above the boiler house, the coal is hoisted from the barge in 15-hundredweight loads by means of a grab and deposited in a main automatic weigher which registers the total coal coming into the power house. From this it is distributed by conveyers to the various storage bunkers, from which it is taken as required, by weighing trucks running along rails over and parallel to the line of boilers, and shot down the required chutes. Thus a check can be kept on the coal consumed by each boiler. A simple contrivance which has long been used by some stations to furnish the man in charge of the coal crane with a check on the amount of coal he is handling is the hydrostatic weigher made by the East Ferry Road Engineering Works Company, Ltd., and which is a self-indicating machine attached to the chain of the crane, and shown in Fig. 6. They operate by effecting a hydrostatic balance between the load and the indicating chamber of the instrument, and their accuracy may be gaged by the fact that a weigher of 1½ tons capacity is graduated in 14-pound divisions, its length overall being only 22½ inches.

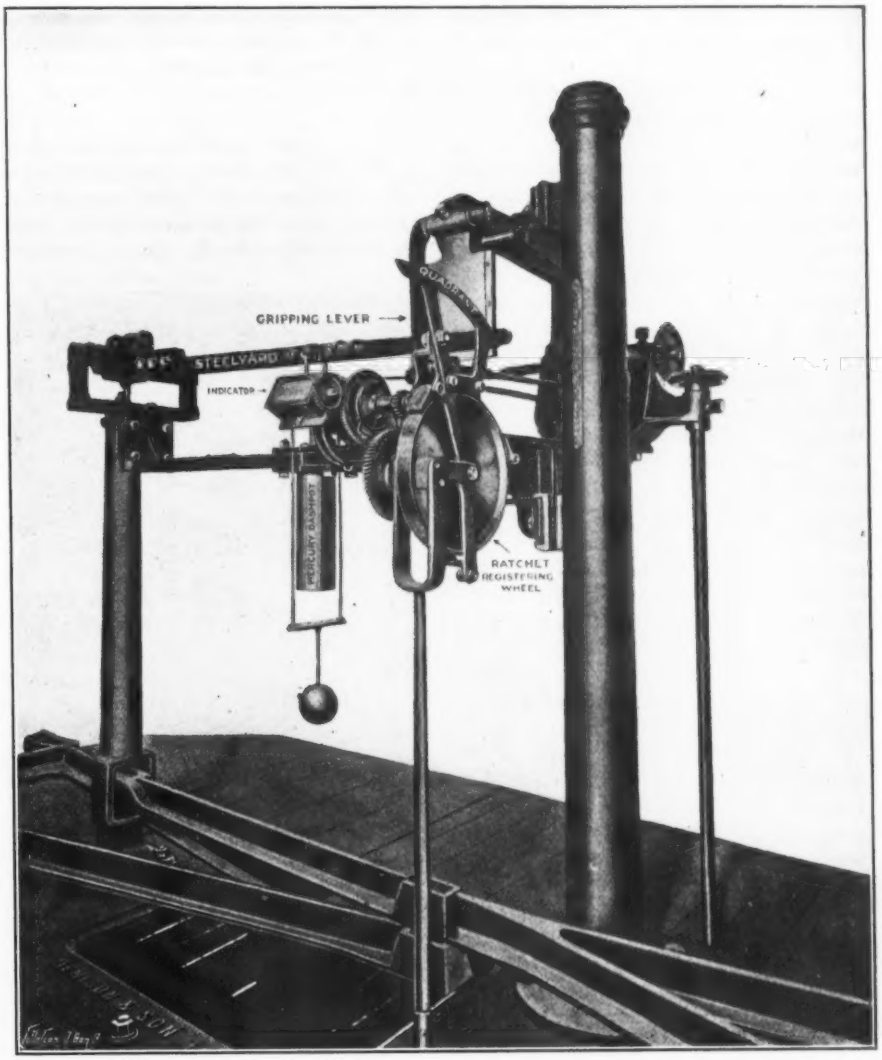


FIG. 9. DENISON CONTINUOUS WEIGHER

Automatic Recording Machine

Frequently, however, automatic records are necessary. A machine which has been accepted by the Board of Trade under the New Weights and Measures Act, and which is finding a place in central-station practice, is the automatic hopper weigher and totalizer illustrated in Fig. 7. This machine, which is made by W. & T. Avery, Ltd., of Birmingham, not only records the weight of each discharge from a grab, but also adds the weights together, so that the total amount of coal passed through the scale can be seen at a glance. An installation of this type has just been fitted in a large works in the North of England, where coal is brought by canal and the barges unloaded by a jib crane fitted with a grab. The machine is mounted on a level with the cabin of the crane, so that the operator has a complete view of the scale, and only one man is required for the operations of unloading and weighing.

The grab is lowered into the barge, fills itself with coal and is then discharged into a large receiving hopper fixed above the weighing machine. This hopper absorbs the shock of the falling coal, which then drops gently into the actual weighing hopper below. As soon as this is reached the weighing mechanism is automatically set in motion, and the weight of the coal is registered on a special counter which automatically adds together all the weights recorded by the machine in such a manner that the total for any period can be read at a glance. When the registration is completed a door automatically opens and discharges the coal, closing again when the hopper is empty. The coal then falls from the scale to a conveyer leading to the bunkers. The application of this

weigher to the coal intake of a large London lighting station is shown in Fig. 8.

Cases have arisen where engineers in charge of power houses have found that the hopper type of weigher has given them trouble. Where the coal, if in the form of slack, has become damp, it has a habit of "hanging fire" and choking the hopper, interrupting the weighing and also the supply of coal. Moreover, the cutting-off action by which certain volumes or weights of coal are separated out for weighing produces trouble either through the irregular size of coal passing or through leakage, and any jarring action which is transmitted to the knife edges of the weigher dulls them and in course of time renders the weighings inaccurate.

A Continuous Weigher

For these reasons certain electric-supply authorities such as, for example, the Great Western Railway Company at Park Royal, the Leeds Corporation Electric Tramways Department and the Newcastle and District Electric Lighting Company, Ltd., have adopted a form of continuous coal weigher made by S. Denison & Son, Ltd., of Leeds. This weigher, which is worked in conjunction either with bucket, pushplate or tray conveyers, works on the principle of suspending a short section of the conveyer and weighing it, with the material that may be on it, as it passes over this suspension. If 6 feet of the conveyer be suspended, the machine is designed to record the weight of the material on the suspension every time the conveyer travels 6 feet, and in this way the material on each portion of the conveyer is weighed successively and without any interruption to the passage of the coal.

The machine, which is illustrated in Fig. 9, consists essentially of a steelyard balanced to suit the unloaded suspension and arranged to rise accurately in proportion to any load introduced upon it. When the steelyard takes a position indicative of the load upon the suspension rods a gripping device, which operates at intervals governed by the speed of the conveyer, grips the steelyard in the position it has assumed. A measuring quadrant then rotates right-handedly until its curved face comes into contact with the gripped steelyard. The higher the steelyard has risen when it was gripped, the greater is the movement of the quadrant. After the contact of the steelyard and quadrant, the latter moves back to its normal position, carrying a ratchet registering wheel with it, which turns on its axis through an angle proportionate to the hight of the steelyard. This is then released and takes up its position again to measure the next section. The gripping and measuring actions are effected by two cams on a shaft operated by gears from a drum which is revolved by the conveyer itself, and the resistance of the steelyard to the load is provided by a hollow plunger suspended in a bath of mercury, which also forms a dashpot, eliminating oscillation. The accuracy of the instrument is found to be within ½ per cent., and it can operate on belts traveling at the high speed of 500 feet per minute, which is beyond the limit to which the average station engineer is accustomed. Fig. 10 shows its use in an electric-light station at Newcastle-upon-Tyne.

In this article no attempt has been made to discuss the relative uses of bucket, tray, pushplate and screw conveyers, as applied to electric power-station practice, as this would in itself occupy a considerable investigation; neither is it possible to describe the large number of types of automatic stoker which have been tried with varying success in Great Britain. It has been the aim of the writer to demonstrate the large amount of design which has been devoted to securing economical handling and efficient measurement of coal, with as little complexity as is mechanically possible; and in view of the interest which is at present being taken in the proper design of power stations for electricity it is hoped that this summary of English practice, though far from complete, may be of interest in the present day discussion.

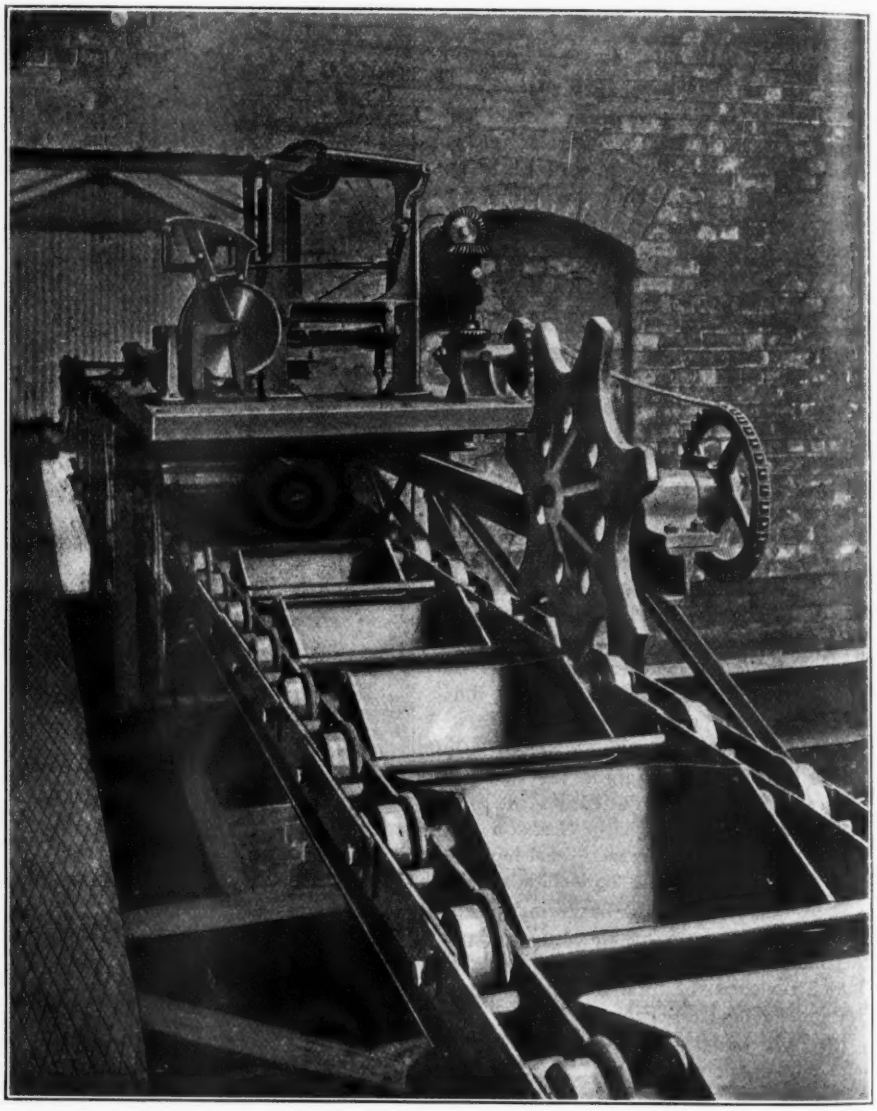


FIG. 10. WEIGHING COAL AT AN ELECTRIC STATION AT NEWCASTLE-UPON-TYNE GRAVITY BUCKET CONVEYER

A Practical Study in Smoke Prevention

By H. S. Knowlton

The prevention of smoke and general improvement of combustion conditions continue to interest operating engineers in charge of power plants, and in the central-station field, of late, especial attention has been paid by executive officers to the broad problem of boiler service. In these instances actual tests of smoke appearance, compared with the recording of definite conditions in the furnaces, have provided valuable suggestions as to the best methods of plant handling. A late

private investigation of this character upon a large Babcock & Wilcox boiler plant equipped with Roney stokers throws considerable light upon the problem of smoke prevention in connection with mechanical firing.

The plant is one of the largest electric-light stations of New England, using high-grade coal of either the New river or Georges creek variety. The stoker installation was made strictly according to the plans and directions of the stoker manufacturers and at the time of the tests represented the best ideas of current practice as applied to the conditions existing.

The plant was not in bad condition from the smoke standpoint when the investigation took place, and with some sacrifice of economy might have been operated with less smoke, with the equipment as installed. It was deemed advisable, however, to improve the conditions without sensible loss in efficiency, and to bring high economy and practically smokeless operation as closely together as possible. The plant was run under normal operating conditions, therefore, and studies made of the equipment with the especial idea of reducing smoke which sometimes occurred with great density.

To find out the causes of the condition continuous observations were taken during several days of the smoke density and the conditions in the fire room were carefully noted. The density of smoke was determined by comparison with a series of charts (following Ringelmann's method) which were placed 50 feet from the observer, between him and the chimney. The conditions in the fire room that were considered as possible causes of smoke were the movement of the pusher plates, the movement of the rocker bars, the pushing of coal upon the grate from the hopper, the poking of coal upon the sides of the grates from the side openings, the slicing between the grate bars, the working of the guards, the dropping of the dumping grate, the cleaning of the grate through the side doors, the amount of opening of the damper, the amount of opening of the ashpit doors and the blowing of the boiler tubes.

During all the tests by the engineer in charge of the investigation all these items were observed for each boiler then in operation, the time at which each event occurred was noted, the amounts of the movement of pusher plates and rocker bars were measured, and the general conditions of operation were recorded. In the normal operation of the plant the individual dampers on each boiler were left open and the draft was controlled by the damper regulator operating the main damper at the chimney. In cases where both smoke and evaporative tests were made at the same time the chimney damper was left wide open, the damper on the boiler under test was set so as to give the desired draft and the dampers on the other boilers were operated by the damper regulator. Sometimes the smoke appeared as late as one minute after the conditions which produced it.

Some of the Results Noted

When all the boilers were controlled by one damper it was found that each time the damper was closed completely there was an increase in the density of the smoke. The heavy smoke did not necessarily continue during the entire period of damper closure, but as a general rule accompanied the change. By reducing the supply of fresh coal the plant could at times, as at the noon hour, be prepared for the closing of the damper and the smoke avoided. The cutting off of an adequate air supply while fresh coal was being forced upon the grate invariably resulted in incomplete combustion.

If the stoker was left to run itself the sides of the grate, for a width of about 10 inches and for about half the distance from the top to the bottom of the grate, were found to be quite bare of coal. With the grate in this condition so large a portion of the total air used went through the bare spaces that the boiler would not develop its proper power, but ran inefficiently on account of the effect of this cooling and unused air. It was found to be absolutely essential to capacity and economy that the sides of the grate should be kept covered. This could not be effected in the stokers as installed without poking coal by hand through the openings provided for that purpose at the sides of the grate, or else by going upon the gallery at the level of the hop- and pushing the coal down by a bar inserted between the hopper plates and the pusher plates. One or the other of these operations had to be performed, in the normal running of the plant, at intervals of from 5 to 10 minutes, in order to keep the fire in proper condition. If the longer interval was used a larger amount of coal had to be pushed down each time, whereas with the shorter interval the labor of the firemen became almost incessant. The engineer who was in charge of the test emphasized in his report that this process of poking coal upon the grate brings a considerable body of fresh coal into a zone of very high temperature and results in the immediate distillation of a large body of hydrocarbons in too large a volume to be burned to complete combustion, consequently causing the formation of smoke. The amount of smoke so formed was extremely variable because the amount of coal so poked by different firemen and at different times is also variable.

The more frequently the poking occurred in any boiler, the less was the smoke produced by each poking. The effects were seen best at those times when there was but little smoke issuing from other causes, as when the damper was well open. If the smoke was already dense there was in many cases no increase in its blackness, but merely an increase in the time of dense smoke. The duration of the smoke from this cause was small, usually not exceeding one minute, but with six 512-horsepower boilers in operation this alone was sufficient to give smoke for a considerable part of the whole period of operation.

Causes of the Smoke

Closing the damper and poking coal upon the sides of the grate were the two main causes of the smoke observed, but there were several other causes of smoke of lesser importance. Any action that causes a considerable disturbance in the condition of the fire will produce smoke. The slicing between the grate bars to dislodge clinkers generally causes only a local disturbance, but sometimes it causes the descent of a considerable body of coal and then produces smoke. The working of the guards is similar in its smoke results, ordinarily having no effect, but now and then causing smoke. The dropping of the dumping grate, if accompanied by a moving of the guard so as to work down the clinker, generally resulted in smoke, but this operation was of infrequent occurrence. Many of the minor-occurrence peaks in the smoke record were due to slipping of coal down the grates. There is often a tendency for the coal to remain stationary for a time, particularly in the upper third of the grate, and then as the pressure behind it increases it slips down for a short distance, usually with the tumbling of a certain amount of fresh coal for a considerable distance down the grates. The smoke from this cause was found to be very variable in amount, but was apparently quite small in general quantity.

Combustion was found to be approximately smokeless if none of the cleaning operations was going on, if coal was not poked upon the sides of the grate, if the damper was well open and if coal was not being fed too fast to the fire. The rate of supplying coal was varied only by varying the amount of the pusher plate, the number of strokes per minute being constant, and the amount of this movement beyond 1½ inches usually increased the density of the smoke. This was not always the case when a fire was being banked, depending apparently on how completely the fire was burned down and how hot the furnace was when the banking occurred.

The Remedies Suggested

The remedies which suggested themselves were in part changes of construction and in part changes of operation. In order to reduce the frequency of closing the dampers several changes were advised. In the operation of the plant at the time of the tests the individual dampers were set so as to give 0.4 inch of draft just over the fire when the chimney damper

was wide open. This draft was sufficient to run the boilers at considerably over their rated capacity. The boilers operate most economically at about their rated power, and it was thought that there would be some gain in economy in reducing the draft in the furnace to about ¼ inch, under which condition they will develop the rated power. This keeps the main damper open a greater part of the time, and the individual dampers can be opened whenever there is an increase in the demand for steam beyond the rated power of the boilers. Making the damper regulator less sensitive was also recommended as a means of decreasing smoke. The plan was to modify it to act throughout a range of about 5 pounds pressure, closing the damper completely at, say, 175 pounds, and opening it wide at 173 pounds, the safety valve being set at 180 pounds, or higher, if necessary. Another desirable change suggested was a better adjustment of the number of boilers in use to the load. This course was intended to reduce the smoke by keeping the damper wide open and also to improve the economy.

It was pointed out that the formation of smoke from the poking of coal upon the sides of the grates is inevitable as long as this poking is not practically continuous. The problem of eliminating the smoke resulting from this operation reduces itself to the question of keeping the entire grate covered by the action of the pusher plate. The pusher plate of this stoker is of the same width as the effective grate, but the coal does not fall upon the sides because of certain resistances which are offered to its movement near the sides of the grate, and apparently also because of a tendency of the coal to move toward the middle of the grate when igniting and caking. The resistances seemed to be offered by the coking arch, which was too low, particularly at the sides, and also by the side walls. It was recommended that the coking arch be cut away for three or four rings, so that it is at no place lower than at the center, and it was also recommended that the side walls be cut away 4 inches, if practicable, for a hight of about 8 inches above the grate and for a distance of about 24 inches down the sides, the depth cut away decreasing to nothing. The reduction of these resistances was tried on one boiler with an improvement in the conditions, but it was not sufficient to keep the sides covered.

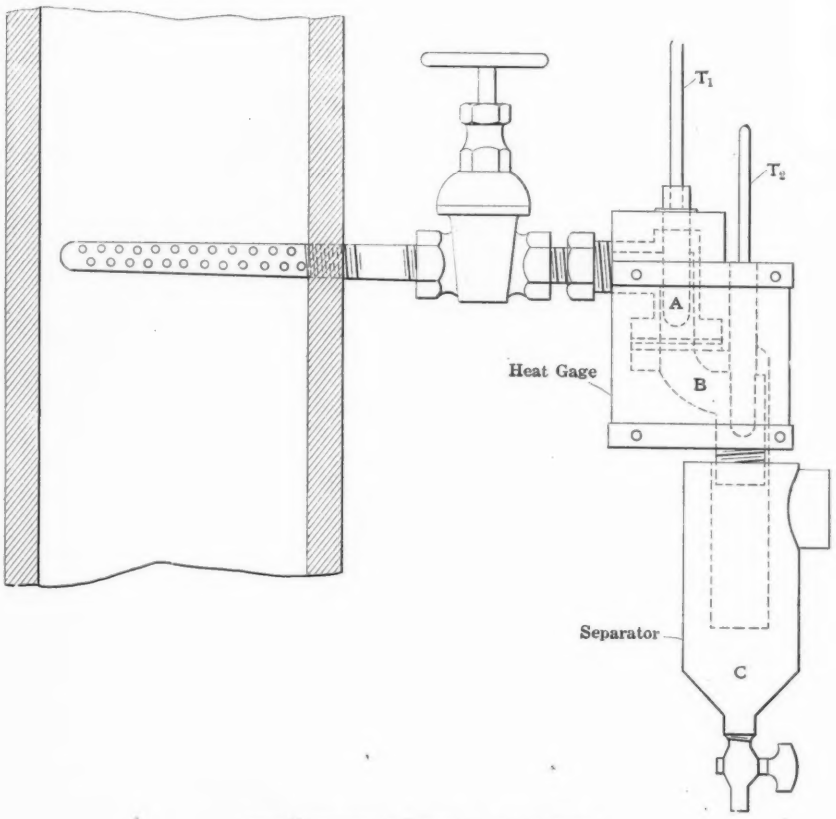
The best method tried to decrease the supply to the middle of the grate was to attach to the throat plate of the hopper a plate which projected into the throat at the middle of the hopper, but which was cut away at the ends so as to offer no obstruction there. To keep the same supply of coal at the middle of the grate the movement of the pusher plate had to be increased, which increased the supply to the side of the grate. After several trials it was found that a plate projecting 1½ inches into the throat and extending from the center to within 10 inches of the end of the hopper gave the best results. The bottom edge of the plate was cut on the slant for a short distance from the end nearest the hopper so that the amount of its projection into the throat decreased from 1½ inches to nothing. It was found that with this plate attached the sides of the grate could be kept well covered when the pusher plate was making a fair stroke, but if the stroke was very small the sides became bare. The plate did not obstruct the passage of the coal when lumpy and easily permitted the use of more coal than could be burned with the maximum draft.

The final recommendation was the adoption of a throat plate projecting 1½ inches into the throat and cut away at the end, with the pusher plate thickened 1½ inches at the end for a length of 10 inches, and then coming down to its regular thickness by an easy curve parallel to the throat plate. A final cause of bareness of the sides of the grate is the difficulty of filling the ends of the coal hoppers. The coal spout cannot be pushed over far enough to fill the ends of the hopper without an effort which is excessive. To remedy this it was suggested to fasten trouble plates 10 to 12 inches high to the ends of the hoppers so that the coal can be well piled up against the ends. It was also suggested that the boilers be run most of the time with the lower ashpit dampers closed and that provision be made for supplying the steam to the ashpits to save the grate bars and aid in getting rid of clinkers.

Steam Calorimeters

By Charles N. Cross

The instrument shown in Fig. 1 is the well-known Barrus "Universal" steam calorimeter. It consists of two parts as indicated, the heat-gage and the separator. The steam passes from the sampling pipe directly into the heat-gage and passes through the separator into the atmosphere. The opening from the separator into the atmosphere is very large compared to the orifice in the disk of the heat-gage. The



THE "UNIVERSAL" STEAM CALORIMETER

pressure in the lower part of the heat-gage and in the separator is always that of the atmosphere. Consequently if the lower chamber, *B*, and the separator contain steam which is known to be dry and saturated its temperature will be about 212 degrees Fahrenheit, varying slightly according to whether the barometer reads above or below 29.92 inches of mercury.

Any calorimeter depending upon the principle of throttling or wire drawing is limited in its range. At a boiler pressure of 150 pounds absolute, the maximum moisture which can be measured is about 5 per cent., and it is less at lower steam pressures. The separator is connected on for the purpose of taking care of the moisture not evaporated in the heat-gage.

When the sample of steam contains less than 5 per cent. of moisture, the separator catches no water and is not used, although it remains connected to the heat-gage.

The heat-gage consists of two chambers separated by a thin metal disk having a small orifice, usually ⅛ or 3/32 inch in diameter, with a thermometer cup in each. The thermometers placed in these will hereafter be referred to as upper and lower, or as T_1 and T_2.

The upper thermometer measures the temperature of the moist steam as it comes from the boiler or steam main; the lower thermometer measures the temperature after throttling has occurred.

To prevent radiation as much as possible the heat-gage is incased in hair felt or some equally good nonconducting material. The whole is then inclosed in a polished metal case as a further safeguard against heat loss.

The principle upon which the calorimeter works is explained in the following equations. Aside from the small losses by radiation the total heat in the steam when it is in the upper chamber must be the same as when it is in the lower chamber. Now we will assume that steam which is just dry and saturated be passed through the calorimeter. Then

$$H_p = H_e + 0.48\,(T_{dry} - 212); \quad (1)$$

and when wet steam is passing

$$H_p - M\,L = H_e + 0.48\,(T_{wet} - 212); \quad (2)$$

where,

H_p = Total heat in one pound of dry and saturated steam at steam-pipe pressure, as found in steam tables,

H_e = Total heat in one pound of dry and saturated steam at calorimeter pressure (in lower chamber),

T_{dry} = Temperature in lower calorimeter chamber when dry and saturated steam is entering it,

T_{wet} = Temperature in lower calorimeter chamber when wet steam is entering it,

212 = Temperature of dry and saturated steam in lower chamber when barometer reads 29.92 inches of *Hg*,

M = Moisture in wet steam in steam pipe—expressed decimally,

L = Latent heat of steam at steam-pipe pressure.

Now subtracting equation (2) from (1) we get,

$$M\,L = 0.48\,(T_{dry} - T_{wet}); \quad (3)$$

therefore,

$$M = \frac{0.48}{L}\,(T_{dry} - T_{wet}). \quad (4)$$

Let C = a coefficient =

$$\frac{L}{0.48 \times 100}.$$

Then the per cent. of moisture M' =

$$M' = \frac{T_{dry} - T_{wet}}{C}.$$

In the above discussion 0.48 has been assumed as the specific heat of steam, but, of course, it is known that it is not a constant for all pressures and temperatures, and the constant C will vary accordingly. The inventor of the instrument made a large number of tests to determine the proper values of the coefficient to use for the various temperatures that would be measured by T_1, and the results are given in the following table:

Temp Shown by T_1; Deg. Fahr.	Coefficient.	Temp. Shown by T_1; Deg. Fahr.	Coefficient.
270	22.0	330	21.0
280	21.8	340	20.8
290	21.7	350	20.6
300	21.5	360	20.5
310	21.3	380	20.2
320	21.1	....	....

Due to the fact that all the radiation losses cannot be eliminated, they are corrected for in the following manner. This method of correction should be used every time the calorimeter is used, because conditions under which radiation occurs are never exactly twice alike.

When dry and saturated steam of a temperature of, say, 280 degrees Fahrenheit is passing, the lower thermometer should read 255 degrees Fahrenheit, but due to radiation losses it really shows a temperature of only 250 degrees Fahrenheit. This lower temperature is called the "normal" reading of the lower thermometer. The normal reading is obtained by taking readings when the fire under the boiler is banked and little or no steam is passing through the main pipe. The pressure should be maintained at such a point that the upper thermometer reads about the same as when the data for quality of steam are taken. The test for normal temperature should be continued for a sufficient time to establish a constant reading for the lower thermometer (usually not less than half an hour). When the pipe between the calorimeter and the steam main is well covered, the normal readings should not vary much from the following:

Temp. by T_1; Deg. F.	Approx. Normal Reading of Lower Ther. T_2; Deg. F.	Temp. by T_1; Deg. F.	Approx. Normal Reading of Lower Ther. T_2; Deg. F.
280	250	340	286
290	256	350	292
300	262	360	298
310	268	370	304
320	274	380	310
330	280	...	...

To obtain the quality of steam when the separator is not necessary:

After the steam has been passing through the instrument long enough to warm it thoroughly, read the two thermometers every two minutes for twenty minutes, and find the average of these readings. Then find the normal reading of the lower thermometer as already explained. Subtract the average reading of that thermometer from the normal reading and divide the remainder by the coefficient which corresponds to the average reading of the upper thermometer, and the result gives the moisture in per cent. If the quantity of the moisture is beyond the limits of the calorimeter, the lower thermometer will show a temperature in the neighborhood of 212 degrees Fahrenheit. When it gets down to 218 degrees or 216 degrees Fahrenheit, it is always wise to use the separator.

There is always a small amount of condensation in the separator due to radiation, which should be determined experimentally for the conditions of the test. It has been found to be not far from 0.13 pound per hour when the surrounding air is at 70 degrees Fahrenheit.

The water from the separator is run through a rubber tube into a receptacle in which it can be weighed every five minutes. This weight minus the condensation gives the net weight of water caught in the separator.

The amount of steam and water passing through the calorimeter per hour at the observed reading of the upper thermometer is determined by actually condensing the steam discharged from the separator and weighing it. This weight of steam added to the net weight of water caught in the separator gives the total steam and water. The net weight of water caught in the separator divided by the total steam and water will give the per cent. of moisture as shown by the separator. This added to the per cent. of moisture obtained from the heat gage in the same time will give the total per cent. of moisture in the steam.

For approximate results it may be allowable to use the normal temperatures given in the foregoing table, and to compute the flow of steam through the orifice by Napier's formula. But for accurate results it is necessary to follow the procedure as given. If results whose errors are within 1 per cent. are desired, great care must be taken in all the manipulations, and thermometers the accuracy of which is undoubted must be used.

Thus it is seen that it is quite a long procedure to determine the quality of steam with this instrument. In commercial work it may be next to impossible to obtain the conditions for getting the normal temperature. Finding the radiation loss of the separator takes considerable time and skill. When all the work is done with care the corrections for radiation losses and for change of specific heat of steam are made. These both are usually neglected in the ordinary forms of throttling calorimeter.

Testing Gas Engines and Motors

Prony Brake and Indicator Tests in Internal Combustion Work; The Running Log, How It Is Made up; Working out Results

BY E. S. FRASH

Before running a test it is always best to run the engine light for a short time in order to limber it up, especially if it is a new one. Preliminary tests should first be run to determine the best loads to carry and, in making automobile motor tests, the most advantageous timing of the spark and the speeds for smooth running should also be determined by experiment.

A record blank for keeping memoranda of tests run should be provided. After a certain test, simply check the test run. This plan gives one a graphic result sheet which shows at a glance all the tests that have been run.

The running log for a motor test should contain the following items:

1. Number of the test.
2. Time.
3. Pounds of gasolene or kerosene used.
4. Cooling water.
   (a) Initial temperature.
   (b) Final temperature.
   (c) Weight in pounds circulated.
5. Revolutions per minute of motor.
6. Weight in pounds on the brake arm.
7. Timing of spark.

Low power tests should be of about fifteen minutes' duration, taking readings every three minutes. High power tests may be reduced in length to five or ten minutes' duration, taking readings every one or two minutes, respectively. The longer the test, the less chance for error.

The running log of a stationary gas-engine test should contain the following items:

1. Number of test.
2. Time.
3. Revolutions per minute of engine.
4. Room temperature.
5. Barometer reading.
6. Gas.
   (a) Cubic feet used for test.
   (b) Temperature.
   (c) Pressure.
7. Cooling water.
   (a) Initial temperature.
   (b) Final temperature.
   (c) Weight of water circulated during test.
8. Weight in pounds on the brake arm, W.
9. Length of brake arm, in feet, L.
10. Timing of ignition.

The average length of a short test should be about thirty minutes, with readings every five minutes.

Final Results of Motor Tests

From the data taken on the running log of a motor test one should record the following direct and derived results:

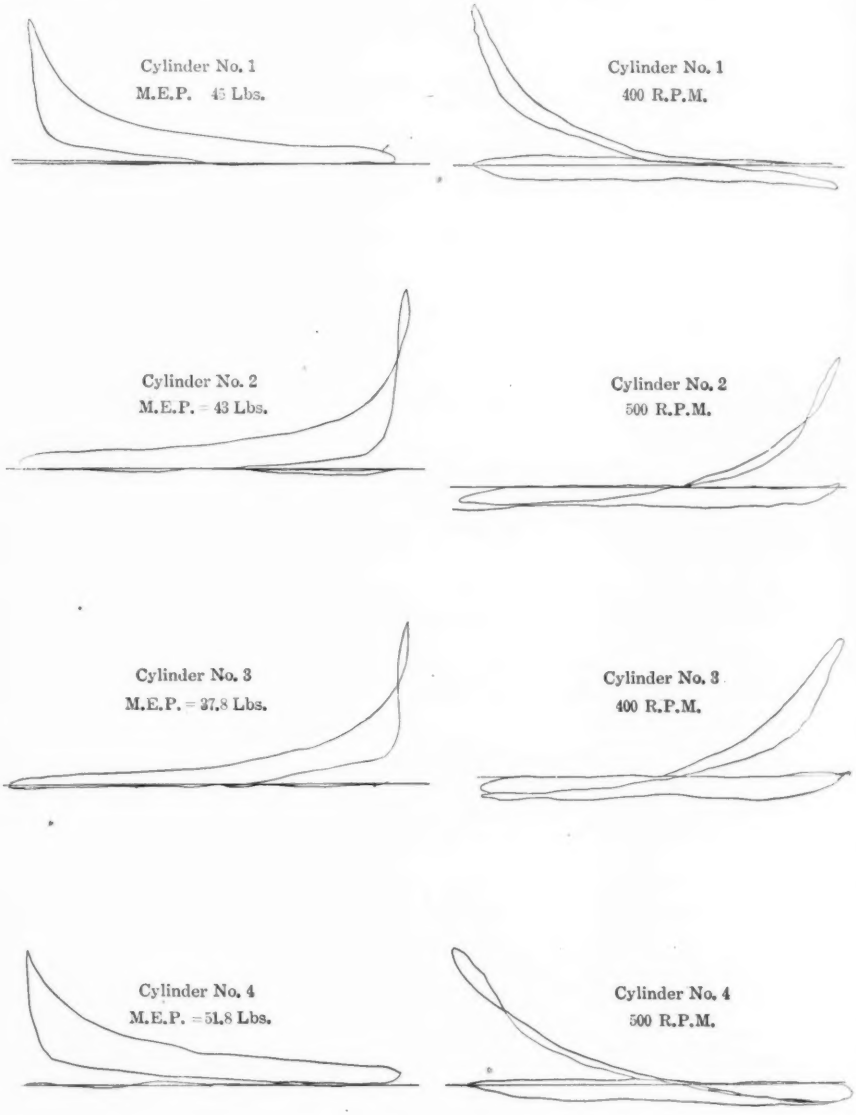


FIG. 1. CLOSED DIAGRAMS TAKEN AT 500 R.P.M., WITH 60 POUNDS ON BRAKE. SCALE 20 POUNDS PER INCH

FIG. 2. NO-LOAD COMPRESSION DIAGRAMS. SCALE 30 POUNDS PER INCH

1. Running test number (from log).
2. Duration of test in minutes (from log).
3. Angle of advance of spark (from log).
4. Revolutions per minute of motor (from log).
5. Brake horsepower =

$$\frac{1904 \times L \times W \times R.p.m.}{10{,}000{,}000}.$$

6. Pounds of gasolene per hour =

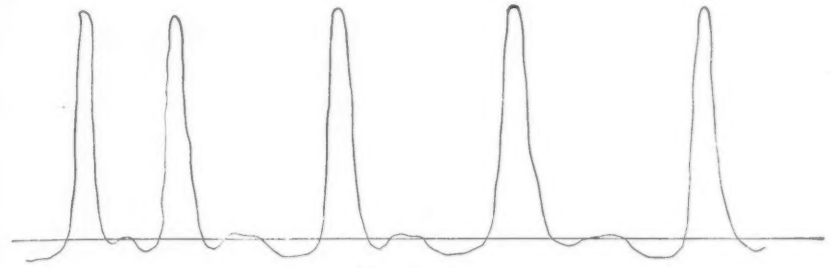
$$\frac{Lbs.\ used \times 60}{Duration\ of\ test}.$$

7. Pounds of gasolene per brake horse-power-hour =

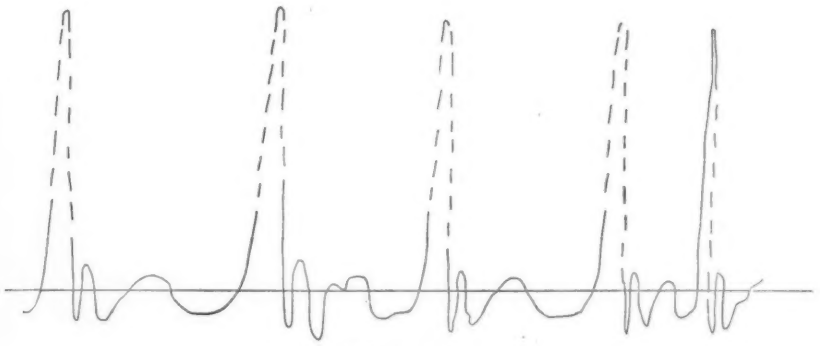
$$\frac{Item\ 6}{Item\ 5}.$$

8. B.t.u. of gasolene per pound (from maker).

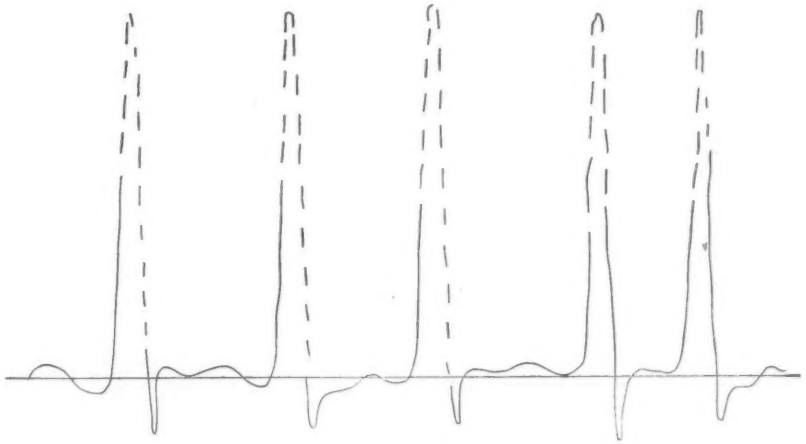
11. Initial temperature of jacket water.
12. Final temperature of jacket water.
13. Pounds of jacket water circulated during test.



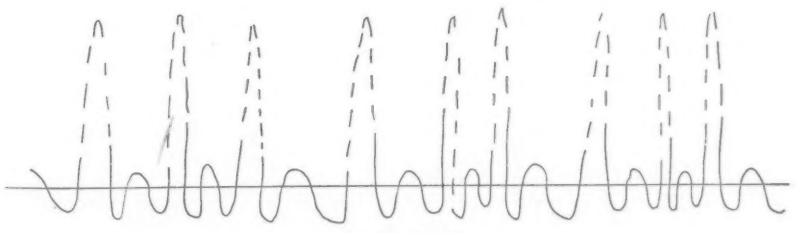
500 R.P.M.



900 R.P.M.



1000 R.P.M.



1200 R.P.M.

FIG. 3. CONTINUOUS NO-LOAD COMPRESSION DIAGRAMS. SCALE 80 POUNDS PER INCH

9. B.t.u. supplied to engine per hour =

$$Item\ 6 \times Item\ 8.$$

10. B.t.u. supplied per brake horsepower-hour =

$$Item\ 7 \times Item\ 8.$$

14. Pounds of jacket water per hour =

$$\frac{Item\ 13 \times 60}{Duration\ of\ test}$$

15. B.t.u. absorbed by jacket water per hour =

$$(Item\ 12 - Item\ 11) \times Item\ 14.$$

16. Thermal efficiency in percentage =

$$\frac{2545.2 \times 100}{Item\ 10}.$$

17. Heat lost to jacket water, in percentage of supplied heat =

$$\frac{100 \times Item\ 15}{Item\ 9}.$$

The heat value (B.t.u. per pound) of the gasolene may be ascertained from whoever supplies it, as a rule. If this cannot be done, a sample of the fuel should be tested by someone experienced in the use of calorimeters made for such work. In the absence of reliable information on this subject, the heat value may be estimated at 19,000 B.t.u., but this assumption makes the results of the test a little uncertain.

Final Results of Gas-engine Tests

For the prony-brake test, such items as do not pertain to gasolene in the motor test also apply to a gas-engine test. Or the gasolene record can be used by substituting standard gas per hour for gasolene.

Standard gas per hour =

$$\frac{T_s P_1 V_1}{P_s T_1},$$

where

T_s = 460.7 + 62 = 522.7 degrees Fahrenheit (absolute + standard temperature),

P_1 = Barometer reading + pressure of gas in pounds — 14.7; 27.71 inches of water at 62 degrees Fahrenheit = 1 pound pressure per square inch,

V_1 = Cubic feet of gas used,

T_1 = 460.7 + temperature of gas,

P_s = 14.7 = one atmosphere or the pressure in pounds per square inch at sea level.

Indicator Tests

So far the discussion of tests has been confined to the prony-brake test, but the field of engine investigation is immensely widened by the use of the indicator. Following is a description of the salient features of tests made by the writer on a well known gasolene engine in the testing room of Purdue University; these tests can be very easily duplicated on any gas engine. The machine referred to was a four-cylinder four-stroke-cycle, water-cooled engine, rated at 30 to 35 horsepower and designed for a maximum speed of 1600 revolutions per minute. The compression was rated at 75 pounds at 200 revolutions per minute.

The object of the tests was to study the indicated power and cylinder conditions of the motor. Besides a prony brake indicators were used. Two indicators were used and cards were taken simultaneously first from cylinders No. 1 and

No. 3, and next from cylinders No. 2 and No. 4. The indicators were attached directly to the cylinders by replacing the priming-valve caps by caps tapped to take the indicator fitting.

Various diagrams were taken, such as ordinary closed diagrams, Fig. 1; closed compression diagrams, Fig. 2; continuous compression diagrams, Fig. 3; maximum explosion pressures, Fig. 4; speed compression diagrams, Fig. 5, and hand-cranked compression diagrams, Fig. 6. The closed diagrams of Fig. 1 were taken just as ordinary gas-engine cards would be taken. In taking the compression cards in Fig. 2, the ignition circuit to the cylinders being tested was opened, causing the motor to run on the other two cylinders. Otherwise, the diagrams were not the same in all cylinders. Cylinder No. 3 was somewhat irregular and there are not enough data at hand from which to draw definite conclusions as to the cause. Cylinder No. 4 had a comparatively low explosion pressure, which is explained by the fact that it had low compression.

The diagrams at 500 revolutions per minute were taken while cylinders Nos. 1 and 4 were in bad condition. No. 3 was having spark trouble and its low explosion pressure was not due to its valves at this time. The diagrams taken at 700, 900 and 1300 revolutions per minute, used when taking explosion cards, show the effects of valves in poor condition very clearly. The valves of cylinder No. 1 were reground, as before stated, while

Fig. 7 illustrates the effect of speed upon efficiency. The curves were plotted from the results of tests on the same motor which gave the preceding indicator diagrams, and show quite conclusively that while the engine was capable of increased output by running it at higher speeds, the best speed for normal running was 900 revolutions per minute.

Results of Gas-engine Test and Method of Working Them Up

From a running log such as that previously suggested and the indicator diagrams, one is able to obtain the following results:

1. Running test number.
2. Duration of test, in minutes.
3. Revolutions per minute.

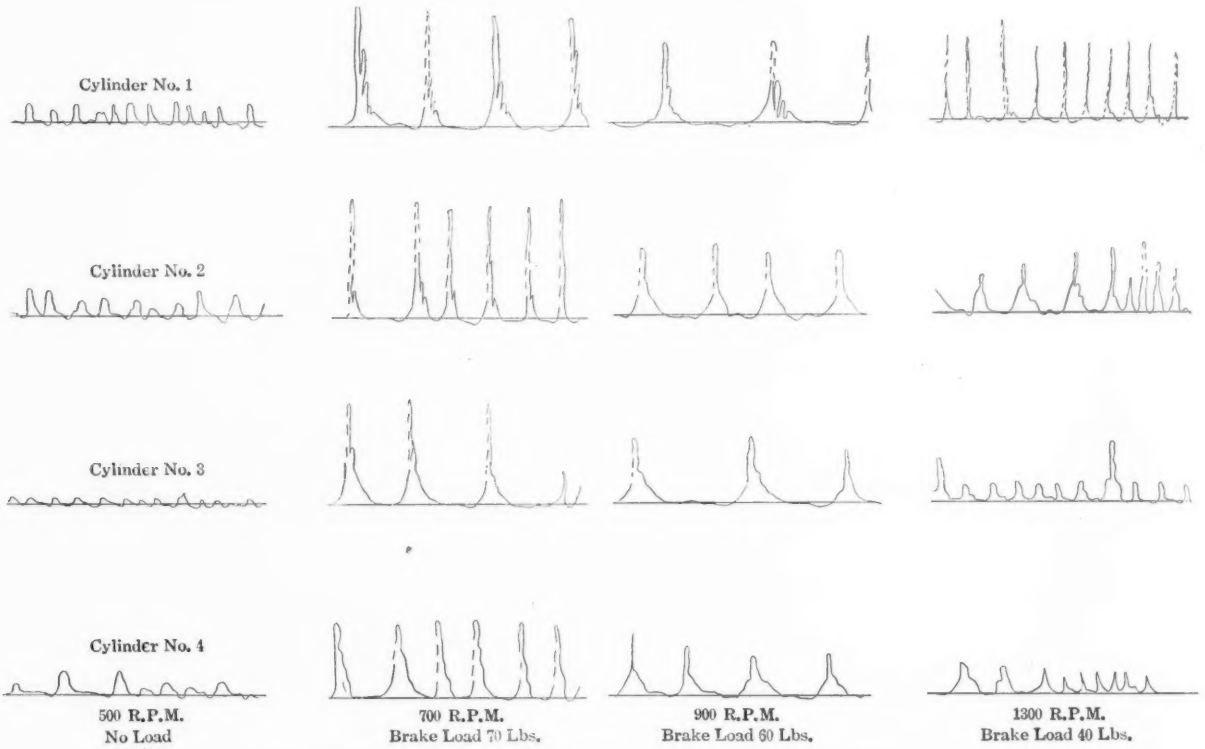


FIG. 4. CONTINUOUS MAXIMUM PRESSURE OR EXPLOSION DIAGRAMS

taken in the same way as those in Fig. 1. In taking the remaining diagrams, the cord from the indicator drums was disconnected from the engine and the cord pulled by hand.

From the diagrams the following conclusions were drawn:

On comparing the diagrams of Fig. 3 from the different cylinders, it is evident that there is a large variation in compression pressure. This variation was no doubt largely due to the condition of the valves, and partly to leakage past the piston. The engine was designed to have 75 pounds compression at 200 revolutions per minute, but as the diagrams show, it fell short of this during the tests. The maximum explosions and power fell short in the same proportion.

From the diagrams in Fig. 4 it is obvious that the explosion pressure was No. 4 was left in its poor condition for a comparison.

The cards here shown tell the same old story, that no matter how good the ignition system, the valves, the real backbone of any engine, must be properly ground and cared for in order to obtain the maximum efficiency of the engine.

From the compression diagrams, Figs. 5 and 6, it is evident, as indicated by Fig. 2, that the engine had not the designed compression, for at 500 revolutions per minute the compression was much less than 75 pounds, and the compression decreased as the speed increased. Comparing the cylinders, the diagrams show that the cylinders work more uniformly as to compression than as to explosion; the probable reason is that the spark coil did not seem to work quickly enough on high speeds.

4. Brake horsepower $=$

$$\frac{1904 \times L \times W \times R.p.m.}{10{,}000{,}000}.$$

5. Explosions per minute.
6. Mean effective pressure (from indicator diagram).
7. Indicated horsepower $=$

$$\frac{Item\ 5 \times Item\ 6 \times Piston\ area \times Stroke}{33{,}000}$$

8. Friction horsepower.
9. Mechanical efficiency $=$

$$Item\ 4 \div Item\ 7.$$

10. Pressure of gas in inches of water.
11. Temperature of gas degrees Fahrenheit.
12. Cubic feet of gas used during test.
13. Cubic feet of gas used per hour.
14. Standard gas per hour.

15. Standard gas per indicated horsepower-hour =

Item 14 ÷ *Item* 7.

16. Standard gas per brake horsepower-hour =

Item 15 ÷ *Item* 4.

17. B.t.u. per cubic foot of standard gas.

18. B.t.u. supplied per indicated horsepower-hour =

Item 15 × *Item* 17.

19. B.t.u. supplied per brake horsepower-hour =

Item 16 × *Item* 17.

20. Initial temperature of jacket water.

21. Final temperature of jacket water.

22. Weight of jacket water circulated during the test.

27. Heat to jacket water =

$$\frac{\textit{Item } 24}{\textit{Item } 14 \times \textit{Item } 17}.$$

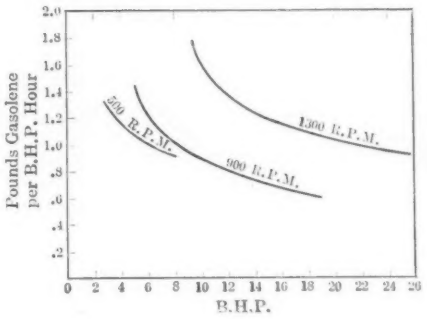


FIG. 7. CURVES SHOWING GASOLENE CONSUMPTION AT THREE DIFFERENT SPEEDS; IGNITION ADVANCED

Horsepower of Motors for Electric Elevators

By N. A. Carle

The horsepower of a motor to be used for elevator service depends upon the load to be raised, the speed of travel of the elevator and the efficiency of the power-transmitting mechanism between the motor terminals and the load which is lifted.

In the design of electric elevators it is usual to counterbalance the weight of the cage so that the net load to be raised consists of the load carried in the elevator. If the load is under- or over-counterbalanced, then this amount must be added to or deducted from the live load to get the actual load.

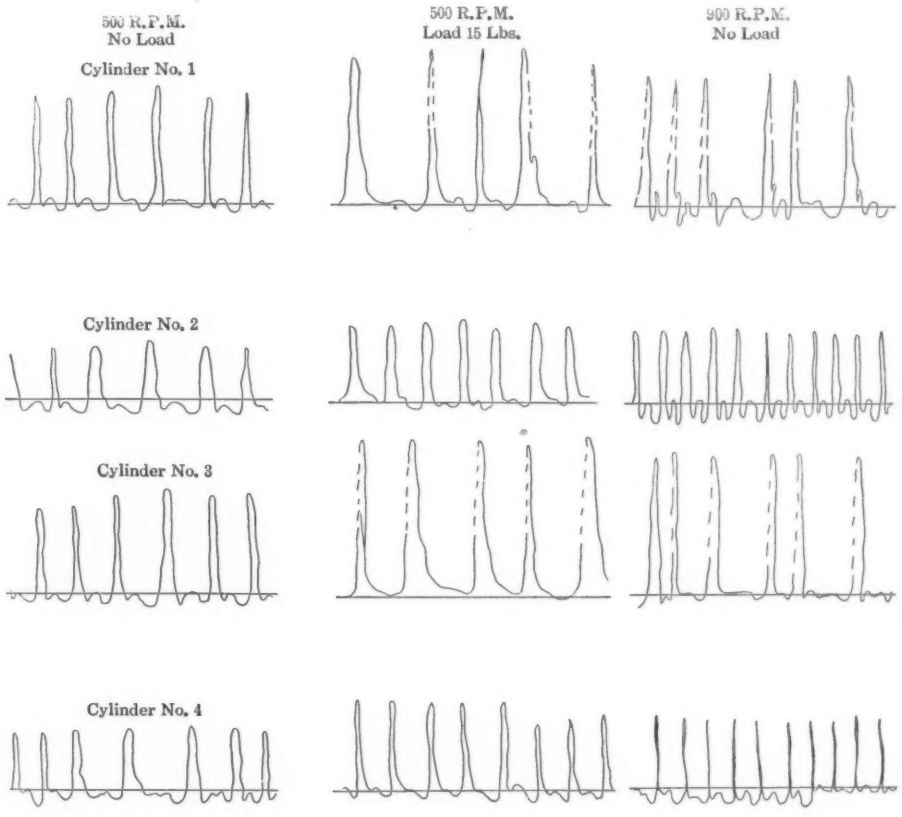


FIG. 5. CONTINUOUS COMPRESSION DIAGRAMS AT DIFFERENT LOADS AND SPEEDS. SCALE 20

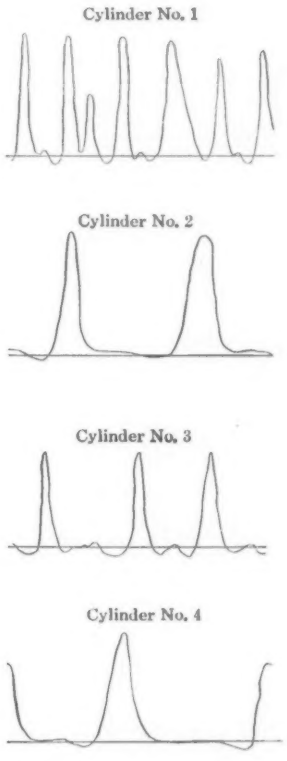


FIG. 6. CONTINUOUS NO-LOAD COMPRESSION DIAGRAMS, TURNING ENGINE OVER BY HAND. SPRING 20

23. Weight of jacket water per hour.

24. B.t.u. absorbed by jacket water per hour =

(*Item* 21 — *Item* 20) × *Item* 23.

Heat Balance

25. Heat equivalent of work =

2545 × *Item* 4 ÷ *Item* 19.

26. Heat equivalent to engine friction =

$$\frac{2545 \times \textit{Item } 8}{\textit{Item } 19}.$$

28. Heat to exhaust and radiation =

1 — (*Item* 25 + *Item* 26 + *Item* 27).

Thursday evening, December 17, Dr. William H. Tolman, director of the American Museum of Safety, addressed a conference in the board room of the American Society of Mechanical Engineers, Engineering building, New York, giving his illustrated study, on the "Museum," which was recently given in Washington by invitation of Secretary Straus, before the Council of Commerce.

The speed of travel usually ranges from 75 feet per minute for freight loads to 300 feet per minute for passenger service.

The operating mechanism between the motor terminals and the load consists of the motor itself, worm gearing to reduce the speed of the motor shaft to that suitable for the winding drum, and the driving parts between the worm gearing and the load, comprising the winding-drum shaft, transmission shafting, journal boxes, sheaves and wire cables. The efficiency of power transmission through

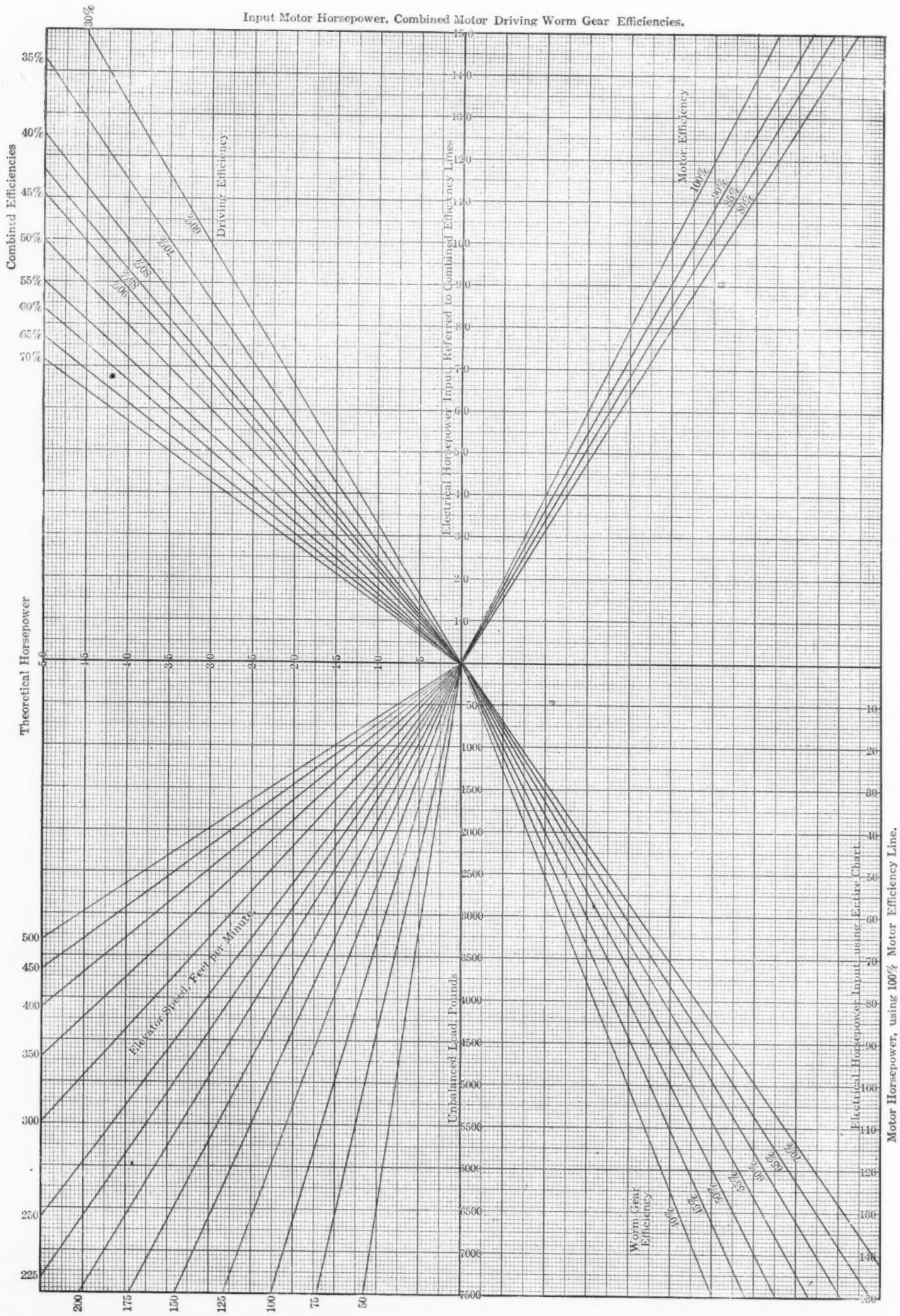

Input Motor Horsepower, Combined Motor Driving Worm Gear Efficiencies.
Combined Efficiencies
Driving Efficiency
Motor Efficiency
Theoretical Horsepower
Elevator Speed, Feet per Minute.
Electrical Horsepower Input, Referred to Combined Efficiency Lines
Unbalanced Load, Pounds
Worm Gear Efficiency
Electrical Horsepower Input, using Ecline Chart.
Motor Horsepower, using 100% Motor Efficiency Line.

CHART FOR CALCULATING THE HORSEPOWER OF MOTORS FOR ELECTRIC ELEVATORS

these various members is called motor, worm gearing and driving efficiencies.

The formula for calculating the horsepower of a motor for electric service is as follows:

$$Horsepower = \frac{L \times S}{33{,}000 \times E_m \times E_g \times E_d},$$

where

L = Unbalanced load in pounds,
S = Speed of travel in feet per minute,
E_m = Motor efficiency,
E_g = Gearing efficiency,
E_d = Driving efficiency.

It is often convenient to combine E_m E_g and E_d into one efficiency which is the product of the three and is called the combined efficiency.

The chart on page 1082 is intended to show graphically how to ascertain the horsepower required when the above factors are known.

The motor and driving efficiencies are shown for from 80 to 90 per cent. and the worm-gear efficiency for from 40 to 70 per cent. The additional lines in the section for driving efficiency are used for the combined efficiency by reading the figures at the top of the chart and those on the horizontal line for the electrical horsepower referred to the combined efficiency lines.

EXAMPLE

What horsepower motor should be installed for a passenger-elevator service which will have an unbalanced load of 3000 pounds and a speed of travel of 250 feet per minute, if the driving efficiency is 90 per cent., the motor efficiency 85 per cent. and the worm-gear efficiency 60 per cent.?

Starting with 3000 pounds load, read up to 250 feet per minute, then across to 90 per cent. driving efficiency, then down to 85 per cent. motor efficiency, then across to 60 per cent. worm-gear efficiency, which is the input that the electric motor must take.

In reading across from the speed of travel to the driving efficiency the theoretical horsepower is shown as 22.5 by the intersection of the horizontal line with the vertical line marked "theoretical horsepower." The combined driving, motor and worm-gear efficiency is the product of $90 \times 85 \times 60 = 45.9$ per cent.

Starting with 22.5 theoretical horsepower and reading across to a point corresponding to 45.9 per cent. combined efficiency, and then down to the horizontal line, the same value of 50 horsepower is obtained.

EXAMPLE

How many pounds of unbalanced weight will a freight elevator driven by a 60-horsepower motor lift at 150 feet per minute if the worm-gear efficiency is 65 per cent. and the driving efficiency 80 per cent.?

Starting with 60 horsepower read up to 65 per cent. worm-gear efficiency, then across to 100 per cent. motor efficiency, then up to 80 per cent. driving efficiency and then across to 150 feet per minute, and drop a vertical line from this point to the horizontal line showing load values. The result is approximately 6850 pounds.

The double naming of the bottom left-hand scale and the 100 per cent. motor-efficiency line are provided in order that either the electrical input of the motor or its actual delivered horsepower may be used. When the input is used, then the efficiency of the motor must also be considered, but when the brake horsepower is used, that leaves the question of motor efficiency out entirely and the 100 per cent. efficiency line must be used.

Catechism of Electricity

877. *Can the full-load current of an induction motor be calculated?*

It can if the voltage, power factor and efficiency of the motor are known. If I = full-load current per wire, $H.P.$ = horsepower of motor, E = voltage at the motor terminals, p = power factor and e = efficiency, then for a single-phase motor

$$I = \frac{746 \times H.P.}{E\ p\ e};$$

for a two-phase motor

$$I = \frac{373 \times H.P.}{E\ p\ e};$$

and for a three-phase motor

$$I = \frac{430.7 \times H.P.}{E\ p\ e}$$

SELECTION OF MOTORS

878. *What general considerations should govern the selection of a motor?*

Its material and workmanship should be of the best quality, solid and durable. The various parts should be of ample size for the work assigned to them, as otherwise the machine will be inefficient and will require frequent repair. A machine with a good finish is very seldom poorly constructed, and it is also much easier to keep clean and attractive. As far as possible the various parts of the motor should be plain, simple and interchangeable; complicated parts, unless they have already been tried out and have proved their standard worth, should be viewed with suspicion. The brushes, for example, should be designed to facilitate easy, quick and permanent adjustment. The connectors and other small parts should be arranged so they cannot readily become loose and normally exposed to injury.

879. *How about the form and weight of a motor?*

The motor should be symmetrical; that is, the parts should not project abnormally so as to give the machine an awkward appearance. A very high or very flat machine is both awkward in appearance and clumsy to handle, and is therefore undesirable. To afford stability, the large and heavy parts should be as low as possible. If the shaft is high above the base there will be considerable vibration which, of course, is objectionable, yet it must not be so low as not to afford sufficient room for the proper operation of the belt or other attachment. A low shaft on a horizontally belted machine is liable to cause trouble by reason of the belt striking the floor.

The weight of a motor for stationary use should be sufficient to secure stability. Freedom from vibration, steadiness of operation, strength and durability are largely dependent upon ample weight.

880. *What special features regarding the armature are worthy of notice?*

The armature should turn easily in its bearings and be perfectly balanced. If it is not well balanced there will be a noticeable vibration of the machine when the armature is running at full speed. The end play or movement lengthwise of the shaft in the bearings should be from 1/16 to 1/8 inch, and there should be at least 1/8 inch between the armature surface and pole faces.

The commutator of a direct-current motor should be of sufficient diameter to afford the necessary radiating surface for the heat developed by the current and the friction of the brushes. Under continuous full-load conditions its temperature as measured by a thermometer should not exceed 55 degrees Centigrade above the surrounding air temperature. There should be a sufficient number of commutator bars so that the difference of potential between adjacent ones will be low.

The peripheral speed of the armature, that is, the speed at its circumference, should not ordinarily exceed 3000 feet per minute.

881. *How is the peripheral speed of an armature estimated?*

By measuring the circumference of the armature in feet and multiplying it by the speed of the armature at no load in feet per minute.

882. *What special features regarding the frame are worthy of notice?*

The frame should be so designed that the armature and field coils can be readily taken out. To facilitate moving or lifting the motor, there should be an eyebolt screwed into the top of the frame.

883. *Should a motor be chosen with a large or small margin of capacity?*

It is advisable for a motor to have a considerable margin of capacity in view of future requirements. As the motor consumes power only in proportion to the work it is doing, there is practically no disadvantage, except the slight additional first cost, of having the capacity of a motor 2 or 3 per cent. greater than that actually required at the beginning.

884. *How does the cost of a motor compare with that of other machines of the same size and weight?*

It is greater, owing to the high grade of materials and workmanship that must necessarily be employed in a motor. Motors at bargain-counter prices are the most expensive ones in the end and it behooves the purchaser to deal only with reputable concerns which have the welfare of their customers at heart.

MANAGEMENT OF DIRECT-CURRENT MOTORS

885. *What general considerations should govern the location of the motor?*

It should be located, whenever possible, in a clean, dry, well ventilated place, free from dust and liability to injury, and it should be readily accessible for examination and adjustment.

886. *What points should be observed in unpacking the machine?*

Care should be taken to avoid injury to the motor through neglect or rough handling in unpacking. Be sure that all accessories, such as pulley, keys, base, rails, rheostat, etc., are removed from the packing boxes.

887. *Give directions for the installation of the motor.*

The base or slide rails should be firmly secured to a rigid foundation, wall or ceiling, as the case may be. The machine may then be attached to the base or slide rails, care being taken to set the machine so that the armature shaft is level. Machines should never be installed on foundations which vibrate excessively.

Averaging Instrument for Polar Diagrams

Those who followed the discussion in POWER some months ago about averaging the circular diagrams of recording gages will be interested in a paper upon "An Averaging Instrument for Polar Diagrams," by W. F. Durand, of Stanford University, California, which was presented at the annual meeting of the A. S. M. E. An abstract of the paper follows:

Some years ago the present author called attention in a published note* to a form of integrating or averaging instrument for diagrams plotted in polar coördinate, to which, as is well known, the ordinary planimeter is not applicable. The application of the instrument was at that time considered only for diagrams plotted on straight radial lines, such as diagrams of crank-turning effort, etc. Since that time the use of dial-recording gage instruments which trace a diagram in polar coördinates, but with a curvilinear path of the tracing arm, has become greatly extended, and such gages are now in common use for recording various engineering quantities, mechanical, thermal and electrical.

*Sibley Journal of Engineering, November, 1893.

Recent discussion in the engineering press** has indicated a renewed interest in the question of averaging instruments for such diagrams or charts, and this fact has led to a restudy of the instrument previously described with reference to its use for all forms of diagram of this character.

It is obviously necessary in applying an instrument to such diagrams to presuppose a uniform radial scale. This is exactly analogous to the assumption of a uniform scale for the vertical ordinate in the indicator card when averaging by the ordinary planimeter. This implies simply that equal increments in the radial distance of the tracing point from the center correspond to equal increments of pressure, or voltage, or temperature, or whatever quantity may be under measurement. The problem is, then, for any angle of the disk corresponding to any given period of time, to find the mean radius, and thus the mean pressure, temperature or voltage.

This cannot be done with the ordinary planimeter, since, as is well known, the area of the diagram in polar coördinates

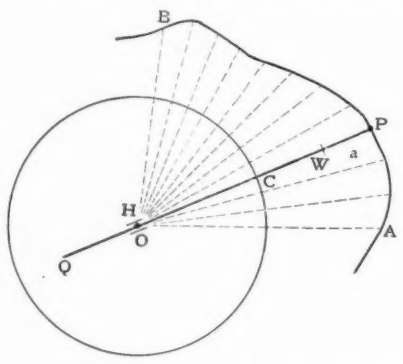


FIG. 1. DIAGRAM WITH RADIAL MOVEMENT OF TRACING POINT

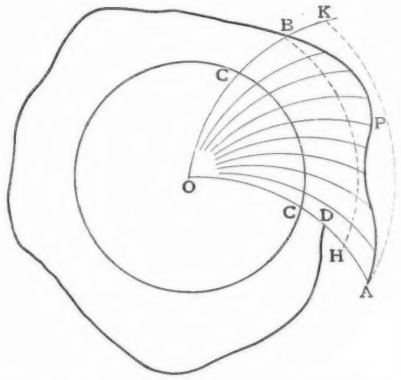


FIG. 2. DIAGRAM WITH TRACING POINT MOVING IN ARC OF CIRCLE

is proportional to the square of the radius and to the angle. By the use of the ordinary planimeter, therefore, the mean square of the radial ordinate can be found, and then the square root of this can be taken. This is not the same as the mean radius, however, a point easily proved by numerical example.

Consider now the arrangement in Fig. 1. Let $A\,B$ denote a curve which for the present we may consider as traced by a point moving in and out on a straight radial line instead of on a curved arc as in most forms of such recording gages. Let O be the center, and at O let H denote a socket pivoted at O and permitting the rod $P\,Q$ to slide freely back and forth as required to permit the tracing point P to follow the curve $A\,B$. Also let W be a wheel carried on $P\,Q$ as an axis and graduated in the same general manner as the integrating wheel of a planimeter. Then it will be plain that the wheel W can respond to movement in angle only, and that movement of the rod $P\,Q$ radially, or in the direction of its own length, will produce no movement and no reading of the wheel W. It is also seen that the movement of the wheel will be proportional to the radius $W\,O$ and that this differs from $P\,O$ by a constant distance $P\,W = a$. It results that the final movement of the wheel W will be proportional to the angle moved through by the arm $P\,Q$, and to the radius $O\,W$ varying from point to point along the curve. As shown in the appendix the reading for any part of the curve, as $A\,B$, is actually proportional to the product of the angle $A\,O\,B$ and the mean radius for the curve between these points. If then we divide this reading by the angle $A\,O\,B$ expressed in circular measure we shall have a quotient proportional to the mean radius $O\,W$. If, then, we add to this the constant distance $W\,P$, we shall have the true mean value of the radial ordinate $O\,P$. If the curve is plotted or drawn with reference to a base circle of radius $O\,C$ as datum, then the radius $O\,C$ being subtracted, the remainder will be the true mean value of the ordinate $C\,P$. If $W\,P$ is made equal to $O\,C$, as may readily be done by a suitable adjustment in the instrument, then the two corrections will balance and the mean value of the radial ordinate $C\,P$ will be given directly as the quotient of the reading of the wheel divided by the angle $A\,O\,B$ expressed in circular measure. If the chart corresponds to 24 hours for a complete circumference, then the angular movement will be $360 \div 24 = 15$ degrees per hour and the angular measure to be used as divisor will be

$$\frac{15 \times 2 \times 3.1416}{360} = 0.2618$$

per hour.

In the usual form of instrument the marking point, instead of moving on a straight radial line as assumed in Fig. 1, moves on the arc of a circle as in Fig. 2. Then in the appendix it is shown that an instrument exactly the same as above described may be used by observing the following general instructions:

In using the instrument for diagrams plotted or traced as in Fig. 2 the tracing

**POWER, March 3, April 27, 1908.

point of the instrument must start and finish at the same distance from the center of the circle. If, then, the diagram covers a complete revolution, as in Fig. 2, with beginning at *A* and end at *D*, it is only necessary to trace from *D* along the curved arc *O D A* to *A*, thus making the start and final finish both at *A*. If the diagram covers only part of a complete revolution, as for example *A P B*, then beginning at *A* the tracing point is carried along *A P B*, and then from *B* along the curved path *B K* to a point *K*, at the same distance from the center as *A*. Or otherwise beginning at *B* the tracing point is carried along *B P A*, and then along *A H* to a point *H* at the same distance from *O* as *B*.

In either case, the reading being taken, the mean radial ordinate is found from it by the same treatment as described above for the straight line radial path.

It is thus seen that the integrating or averaging instrument suited to the treatment of such diagrams is of the simplest possible form, consisting of a plain, straight arm *Q P*, Fig. 1, which serves as axis for the wheel *W* and slides freely through a socket *H* pivoted at the center of the diagram *O*; and that by the use of such an instrument diagrams of this character may be mechanically averaged, no matter what the actual character of the path followed by the tracing point of the recording gage, and no matter what fraction of a complete revolution the diagram may cover.

An Improved Oil Gage

By W. H. Wakeman

Fig. 1 illustrates a cast-iron oil reservoir located on the frame of an engine in my plant. Oil is taken from it to lubri-

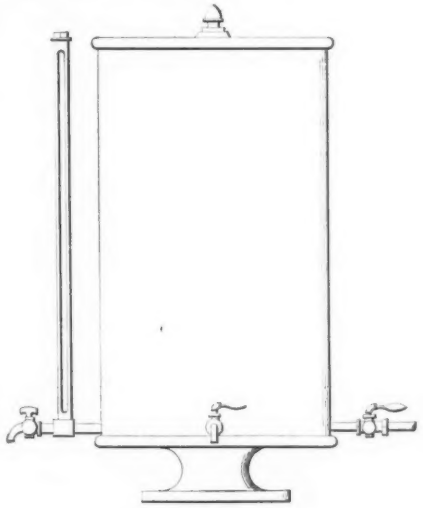


FIG. 1

cate six bearings, the greater part flowing into a tank from which it is pumped into a filter, where it is cleansed and made almost as good as new. This reservoir was fitted with an oil gage such as is commonly used for this purpose, as shown at the left-hand side. It has but one connection to the reservoir, consequently it was necessary to screw a brass rod into the connection to hold the gage glass in place. This rod extended through the center of the glass, and also through a brass washer at the top, and was fitted with a suitable nut at this point. A metal shield encircled the glass, except where two slots were cut to render the glass visible. Cork gaskets were intended to be used at both ends of this glass and when putting in a new one it had to be cut the right length to be clamped by the brass washer, which also held the metal guard in place. If the glass was too long the guard was not held, and if too short

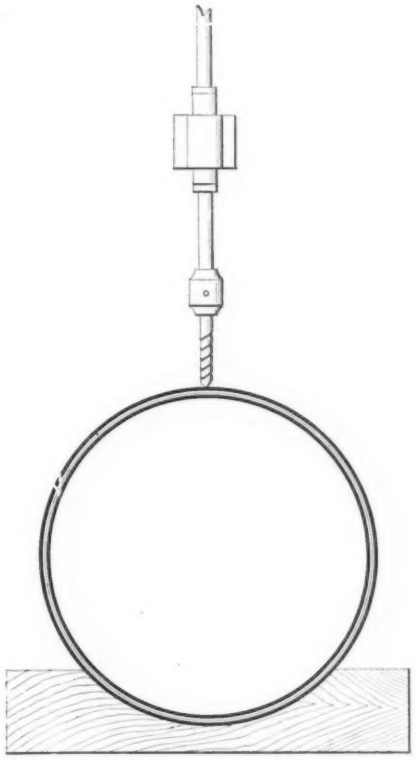


FIG. 2

the glass leaked oil at the bottom. The brass rod inside and the shield outside combined to make it difficult to tell just where the oil level was at all times, and if water commenced to collect in the bottom of the reservoir, it did not show plainly in the glass.

I purchased the upper and lower arms of a lubricator gage and had them nickel-plated. Disconnecting the reservoir and taking it down made it an easy matter to remove the old oil gage and screw in the lower arm. There was no hole for the upper arm, which was ⅜-inch iron-pipe size. Selecting a twist drill 19/32 inch in diameter and a ⅜-inch pipe tap, the required hole was soon drilled and tapped ready for the upper arm. As it was necessary to drill the upper hole in line with the lower, the following device was used to keep the reservoir from rolling: Two pieces of board about 3 inches wide and a foot long were selected. The cover was removed and one of these pieces was laid on top of the reservoir,

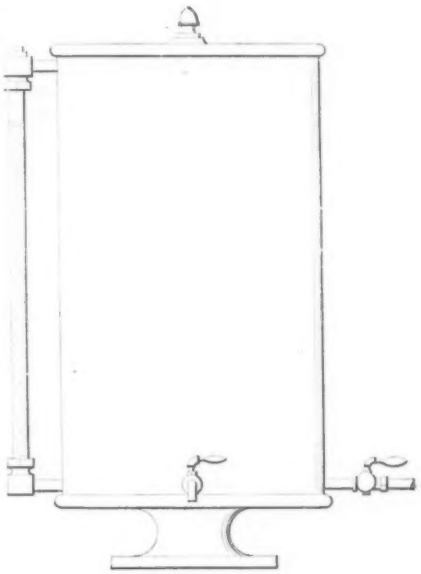


FIG. 3

one side of it projecting over the edge, and on it a part of a circle was marked corresponding to the form of the outer part of the reservoir. This was sawed out with the bandsaw and the other one made to correspond.

It required but a few minutes to do this, and it was much easier and more convenient than strapping it down in the usual way. When these were laid on the drill-press table and the reservoir laid in them ready for drilling, it appeared as shown in Fig. 2, which is an end view of the top. These were sufficient to hold the reservoir in place, but it could be moved easily to secure a correct position.

The completed gage is shown in Fig. 3, and as there is nothing to shade the glass the hight of oil can be determined from a point several yards distant without special effort. It does not show the oil level when the reservoir is either full or almost empty, but whenever the glass is full no doubt can exist of there being a good supply for the bearings, and the reservoir ought always to be refilled before the oil disappears from the glass. While pouring in oil the cover must be removed, and of course no attention is paid to the glass at this time. The fittings cost $2.25.

The electrification of the Italian State railways has made such rapid strides that it has been decided to establish in Milan an office to deal exclusively with all matters relating to the electrification of the various lines. Resort will be had as much as possible to water power, as the Italian government is averse to the importation of foreign coal.—*Electric Railway Journal.*

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Reclaiming Pipe Dies

It may not seem worth while to resharpen a pipe die, but the writer recalls an instance when the sharpening of a discarded ¾-inch die prevented a delay of several days which would have been required for the delivery of a new die. A man may be placed in such a predicament, perhaps, only once in a lifetime, and then he will thank his lucky stars that he knows what to do.

The necessaries for the job are some lead, a fire, a vise, a drill, and a tap the same size as the die. Place the die in the fire, and when it has reached a dull red heat, put it in a vise. Draw up the sides evenly, and slightly, so as to force the cutting edges toward the center of the die. Fill the hollow of the die with lead or babbitt and then drill a hole large enough to start the tap. After the tap has been sent through, melt out the remaining lead and retemper the die.

J. J. O'Brien.

Buffalo, N. Y.

A Repair Job on a Battery of Boilers

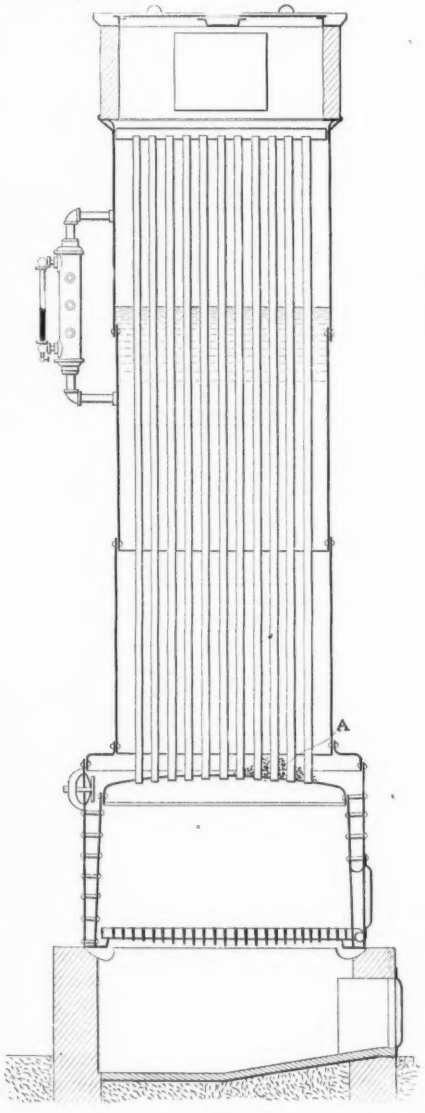
The boilers in question are in charge of a "general superintendent of motive power." While there is not much that is new about re-tubing a boiler that Power readers do not know, it may interest them to know how this job was done.

The battery of boilers, four in number, are of the Manning type, containing 184 2¼-inch tubes, 15 feet long, which are shown in the sectional view. Four tubes started leaking in the back section of one of the boilers, and the matter was reported to the man with the big title at once. He came to the conclusion that as the boilers had been in service ten years, the tubes must be worn out, and the boiler needed new tubes. Therefore, the old tubes were taken out and new ones put in.

The new tubes cost $2.40 apiece, a total of $441.60. The labor charge of boilermakers and steamfitters amounted to $110.40, making a total cost for the job of $552.

The tubes of the remaining three boilers were removed, but instead of replacing them with new tubes, the old ones were sent to the shop and pieces about 8 inches long welded on each and they were replaced.

These boilers were perfectly tight and in the best of condition, capable of doing good service for many years; in fact, in better shape by 100 per cent. than they are today.



SHOWING WHAT CAUSED THE TUBES TO LEAK

Let us see what it has cost the company to make good the general manager's lack of judgment. At *A* is represented a pile of scale which was the cause of the tubes in the one boiler leaking. All that was necessary to repair this boiler was to remove one tube, clean out the scale, and put in a new tube at a cost of $2.40. Allowing five hours for a boilermaker and helper to do the job, at 32 cents and 22 cents, respectively, per hour (the wages this company pays), makes $2.70 for wages, or a total of $5.10 for the job, a difference of $546.90.

As to the cost of repairing the remaining three boilers, the writer was unable to obtain data, but believes $500 a very close estimate, making a total cost of $1052 for the four boilers.

Dewitt Smith.

Somerville, Mass.

Centrifugal Pump Experiences

A short time ago a second-hand 6-inch centrifugal pump was installed in the sugar factory in which I am employed, in place of a very costly 7-inch high-lift pump of the same type, which, although in a very good condition, required an excessive speed to operate efficiently against a comparatively low head. It might be mentioned, in justice to the makers of the discarded pump, that with a slight increase in speed over that required at a 40-foot head it would lift water as high as 90 feet without much trouble, showing that it was efficient only when operated under the conditions for which it was originally designed.

The head under which we were working was only 40 feet, including head due to friction in the piping, but the 6-inch pump called for a higher speed than the engine was capable of giving, without troublesome heating of the bearings.

The real cause of the trouble was the fact that the impeller of the pump was very badly worn and the attendant slippage called for a much higher speed than would have been necessary had things been right in the pump casing. No new pump being available, an impeller from an 8-inch pump was turned down and fitted to the 6-inch pump.

The results of this change were extremely gratifying. With the original impeller, speeds of 668 revolutions per minute and 712 revolutions per minute gave but 2 and 3 inches of water, respectively, in a 15-inch rectangular flume at the head above given; while to obtain the required 6½ inches, or 1200 gallons per minute, was practically impossible. With the improvised impeller, however, a speed of 648 revolutions per minute fulfilled the requirements admirably.

On another occasion, the efficiency of a 4-inch pump was materially increased by

putting a plate between the flat side of the impeller and the casing, thus making up for the worn impeller, but the results in this case were not so marked as in that of the larger pump when the impeller itself was changed.

RENTON HIND.

Kohala, Hawaii.

Wants to Make a Condenser

I should like advice as to how to construct a good condenser for condensing exhaust-steam heating returns, and an arrangement for connecting it to a pump.

M. D. CASPER.

Beaver Dam, Wis.

A Simple Method of Finding Horsepower

The common formula for horsepower is:

$$Horsepower = \frac{P\,L\,A\,N}{33{,}000}, \qquad (1)$$

where

P = Mean effective pressure,
L = Length of stroke in feet,
A = Area of piston in square inches,
N = Number of strokes per minute.

The mean effective pressure is determined by the indicator and is:

$$P = \frac{a \times s}{l},$$

where

a = Area of diagram,
s = Scale of diagram,
l = Length of diagram.

Substituting this value for P in formula (1) we have:

$$Horsepower = \frac{a \times s \times L \times A \times N}{l \times 33{,}00}. \qquad (2)$$

For a given engine running at a fixed speed all of these factors except the area of the diagram are constant, so that we may write:

$$Horsepower = a \times \frac{s \times L \times A \times N}{l \times 33{,}000}, \qquad (3)$$

and, substituting the known values, compute the value of the latter portion and have:

$$Horsepower = a \times Constant. \qquad (4)$$

To make this plain, take for example a 14x20 engine running at 240 turns per minute, with a reducing motion which gives a 3.5-inch diagram. Suppose a 60-pound spring to be used, then

s = 60 pounds per inch,
$L = \frac{20}{12}$ feet,
A = 153.94 square inches,
N = 480 strokes per minute,
l = 3.5 inches.

Substituting these values in formula (3) we have:

$$Horsepower = a\,\frac{60 \times 20 \times 153.94 \times 480}{3.5 \times 12 \times 33{,}000};$$

$$Horsepower = 63.984\ a.$$

That is, the engine will develop 63.984 horsepower for each square inch of diagram produced, and if we get a diagram with 2.44 square inches of area the horsepower will be:

$$2.44 \times 63.984 = 156.12\ horsepower.$$

In a case where the speed is not uniform the N can be left out of the constant and the formula becomes:

$$Horsepower = a\ N\ Constant.$$

Now with our feet on the corner of our roll-top desk, a 2x4 corn-cob pipe of requisite age between our teeth, with a pencil and tab we may antedate the previous work, and when the agent comes in to show us one of the newest in the indicator line, we say:

"Yes, just hook up and give us a sample." When he hands us a card we dig down in one of the drawers and fish out our planimeter and proceed to roll the diagram. He interferes with:

"Don't use that antiquated instrument on indicator work, take my $c\ g \times l\ y$ instrument that gives the mean effective pressure direct."

But we have the area of the card by this time, and simply hand him the board and very interestedly and in great wonderment watch the trained, nimble fingers trace the diagram, and hear him say:

"Now there's your mean effective pressure direct."

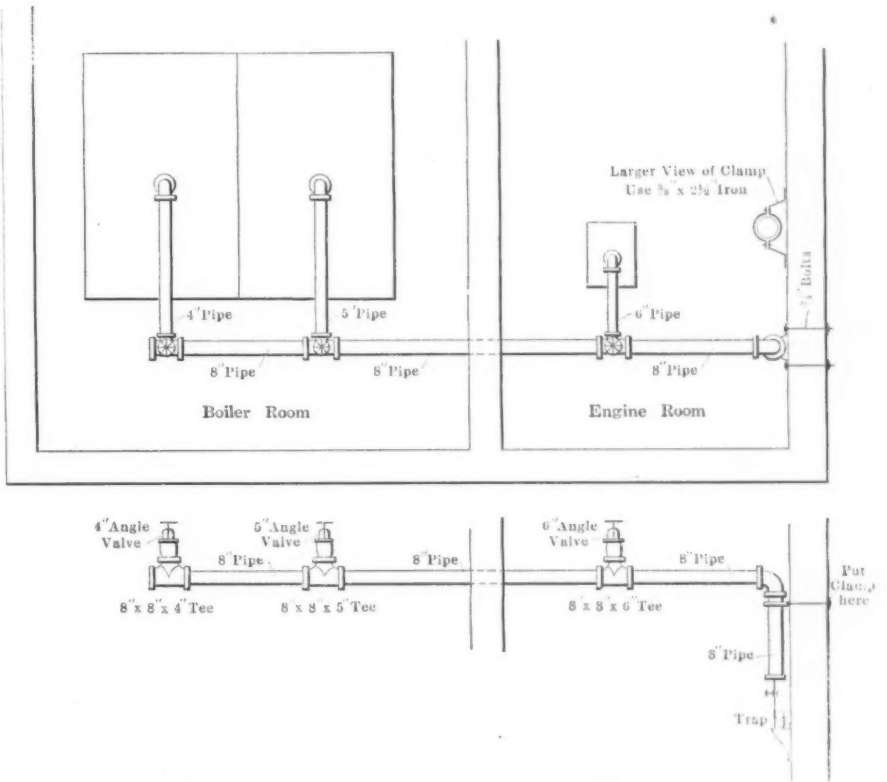
With a grunt that stands for "Yes?" we give him $L\,A\,N$ and we reach for our slide rule, or grab our pencil, and by the time he has found the area we call out the indicated horsepower. If he is acquainted with the slide rule he will think us a "crackerjack;" if not, the fun is ours.

PETER KNOPP.

Kansas City, Mo.

Remedy for Pipe Vibration

The illustration presents a method of piping which may help Richard Owen, who, in the October 27 issue, page 703, describes his trouble with vibrating boil-



MR. JUNG'S SUGGESTION FOR REMEDYING PIPE VIBRATION

ers. I believe this manner of piping will remedy matters.

JOHN S. JUNG.

Milwaukee, Wis.

In the October 27 issue, Richard Owen mentions trouble caused by excessive boiler vibration. This is evidently due to the high velocity of the steam being checked by the engine cutoff.

The remedy would be in an arrangement that will either give less steam velocity, or a less abrupt check to the flow of steam at the present velocity. The first case would require a larger steam opening from the boilers to the engine throttle. The second can be obtained by placing a separator close to the engine having a sufficiently large area.

Another method would be to place a

steam reservoir, made from a piece of 8- or 10-inch pipe, from 3 to 5 feet long, next to the engine. This, however, will give very moist steam. I am in favor of the separator.

L. JOHNSON.

Exeter, N. H.

Long Range Cutoff

A few years ago I was employed in a steam plant generating electricity for a street railroad. The engines were equipped with two eccentrics, being of the cross-compound condensing type. The steam valves were set 60 degrees ahead of the crank. The company owned another steam plant of the same type and horsepower, except that the engines were equipped with one eccentric.

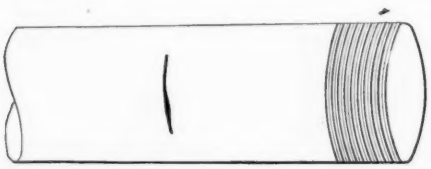
A test was made in the two stations to determine the amount of coal used per kilowatt-hour. Conditions were equal in both plants. In both cases the apparatus was put in the very best condition possible. The engines equipped with two eccentrics used 2.35 pounds of coal per kilowatt-hour, while the engines equipped with one eccentric used 2.75 pounds of coal per kilowatt-hour. This is good evidence as to which arrangement was the more economical.

W. A. Dow.

Cambridge, Mass.

How Blowoff Pipe Split in a Peculiar Way

The accompanying illustration shows how a blowoff pipe split in a peculiar manner. A careful examination showed that the metal was of proper thickness, but cracked crosswise, and, having been in use for years, had become crystallized. The explanation is as follows: Two boilers were used, one at 60 pounds, the other at 90 pounds pressure. The same feed



SPLIT BLOWOFF PIPE

line branched off to both boilers. As the pressure was different, the fireman would occasionally close the feed on the low-pressure boiler, allowing all of the feed water to enter the other boiler. When the water was shut off, the pipe passing through the combustion chamber got sufficiently hot to generate steam which, rising to the top of the pipe, passed along to the boiler. This permitted the upper part of the pipe to get hotter than the lower, causing it to expand more than the lower side. When the feed water was started again, contraction took place, which in time caused the metal to crack crosswise. Upon striking with the hammer, this section of pipe was found to be cracked for a distance of 6 or 8 inches. Boilers working under such conditions should have a new pipe every five years at least, and should be carefully watched.

C. L. DAVIS.

Cincinnati, O.

Trouble with a Duplex Steam Pump

About six years ago a new heating system was installed in a factory power plant, and part of the apparatus was a duplex steam pump to deliver the water

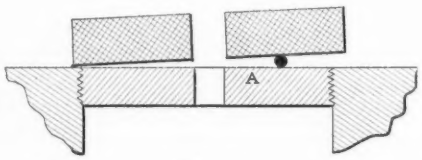


FIG. 1

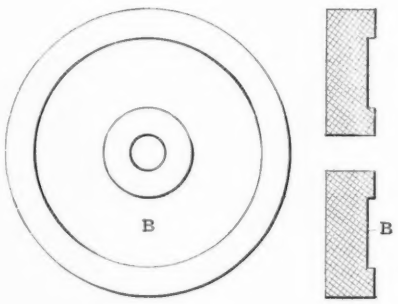


FIG. 2

of condensation to the boiler as fast as received. After everything was ready a trial was made and trouble immediately developed. Small particles of pipe scale or dirt would lodge on the radial webs of the valve seats, as at *A*, Fig. 1. Not only one valve but a number would be affected at the same time, which was sufficient to put the pump out of business. Of course, the only thing to do was to take the valves out and clean them, which was done from one to six times daily.

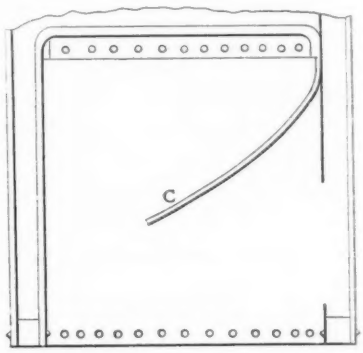
Then the plan shown in Fig. 2 was tried, with decided success. The valves were put in a lathe and 1/16 inch was removed at *B*, leaving the edge and center only to touch the seat. The valves now wear evenly at both points and although examined only once a year, have always been found in perfect condition.

J. A. MAWHINNEY.

Franklin, Penn.

A Boiler Explosion Experience

The writer has had one experience with a boiler explosion. It was an old type of upright boiler, 44 inches in diameter and about 8 feet long. The plates were made of charcoal iron. They were much reduced by constant rust, and the rivet heads on the outside and middle



HOW FIREBOX SIDEWALL GAVE WAY

were reduced to at least one-half their original size.

As shown in the illustration, the sidewall of the firebox gave way, tearing close around the cast-iron mud ring at the bottom, and bending out as at *C*. This plate tore about one-third the distance around the circle of the firebox.

Now, my theory for this explosion is that gas generated within the boiler, which had been standing for three months during the summer with the same water in it. Many years have passed since, and I have observed that the cause of the majority of boiler explosions could be traced back to impure water.

M. R. CAHILL.

Lynchburg, Va.

Bracing a 78-inch Boiler

In the November 10 number, on page 811, there is an inquiry as to the number of braces required for the head of a 78-inch boiler. The answer given does not seem to be justified by the facts. It has been said that "the strongest chain is no stronger than its weakest link." Why, then, should a McGregor brace be figured on another basis?

We would use 7/8-inch rivets in a brace such as that referred to, which would require a 15/16-inch hole. This deducted from 3¾ inches, the width of the brace, would leave $2.8125 \times 0.5 = 1.4062$ square inches effective area. This times 6000 equals 8437 pounds per brace, which would require $148{,}200 \div 8437 = 17 +$ braces; in this case we would use eighteen braces.

H. M. PURNELL.

Miamisburg, O.

Packing for Ammonia Compressors

The refrigerating section of our plant consists of two 12x24-inch Linde British compressors, direct-connected, one on each side, to a 16 and 30 by 24-inch cross-compound Wheelock engine, running at 64 revolutions per minute. Also, we have a brine system, and our compressors are of the wet-compression type. The machines are run about six hours a day, but as the temperature of the mixture the brine is required to cool varies continually, the temperature of the compressor piston rods is constantly changing.

We have experimented with several kinds of packing in various combinations; we first tried using one ring of a canvas-and-rubber packing, followed by several rings of square braided cotton, then another ring of canvas and rubber, and more cotton; this worked fairly well and lasted about three months. Then we tried using all cotton, but could not keep the glands from leaking. Next, someone recommended a sectional ring packing of canvas and rubber, but this was an absolute failure, for it expanded so much and so readily that one minute the glands were leaking like sieves, and the next the rods were smoking hot.

We are using at present alternate rings of fine, square braided cotton and plain piston packing. This gives good service for four months, but must be handled with care at the start, and be carefully fitted to the rods and boxes.

I am under the impression that every four months is too often to have to repack our stuffing boxes, and would welcome any suggestions pertaining to this subject.

A. J. TAYLOR.

Nanaimo, B. C.

Eccentric and Rocker Arm

If the eccentric rod and hook rod run parallel to the center line of the engine, the rocker is usually straight. If they run at an angle to the center line of the engine, then the rocker must be at an angle. Where the rocker arm operates at least two valves, one on each end of the cylinder, the rocker must travel an equal distance each side of a center line that is perpendicular to the center line of the rod to which it is attached. Nearly all of this work can be laid out with a square, as shown in Figs. 1 and 2. These figures also show the center lines of the rods and rockers, which are drawn out in full in Figs. 3 and 4.

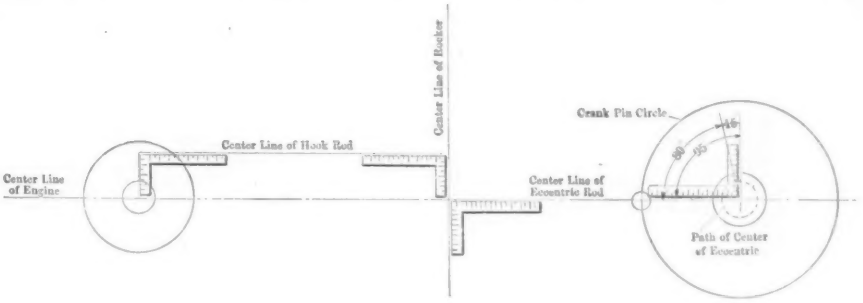

Center Line of Rocker
Crank Pin Circle
Center Line of Hook Rod
Center Line of Engine
Center Line of Eccentric Rod
Path of Center of Eccentric

FIG. 1

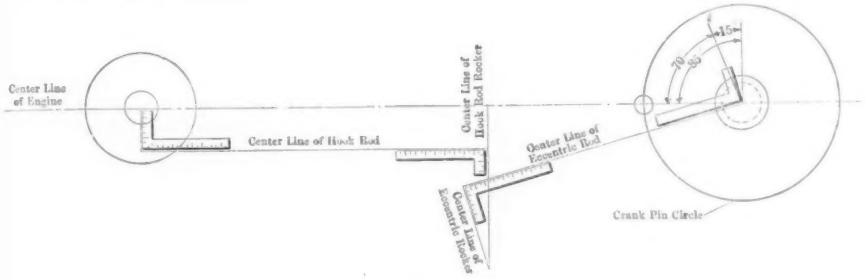

Center Line of Engine
Center Line of Hook Rod
Center Line of Hook Rod Rocker
Center Line of Eccentric Rod
Center Line of Eccentric Rod
Crank Pin Circle

FIG. 2

When the wristplate is in the center of its travel the rocker must be in the center of its travel, or square with the rod, and the eccentric, neglecting the angularity of the rod, would be square with it. The dotted circles in Figs. 1 and 2 show the path of the center of the eccentric. With one point of a tram in the center of the rocker pin and the other in the center of the shaft, draw a line up through the dotted line and the point of intersection is the true position of the eccentric at half travel. In Figs. 1 and 3 it is about 80 degrees and in Figs. 2 and 4 it is about 70 degrees with the center line of the engine.

This brings up another question: With a direct valve and direct rocker and the engine running over, the eccentric is set at 90 degrees with the crank, plus the angle of advance, and while this is true in Figs. 1 and 3, it is not true in Figs. 2 and 4. Suppose the angle of advance is 15 degrees; in Fig. 1 the position of the eccentric would be 95 degrees with the crank, but in Figs. 2 and 4 the eccentric is only 85 degrees with the crank, but they are both 95 degrees with the center line of the eccentric rod. In order to make this rule apply to both it should read 90 degrees with the center line of the eccentric rod, plus the angle of advance.

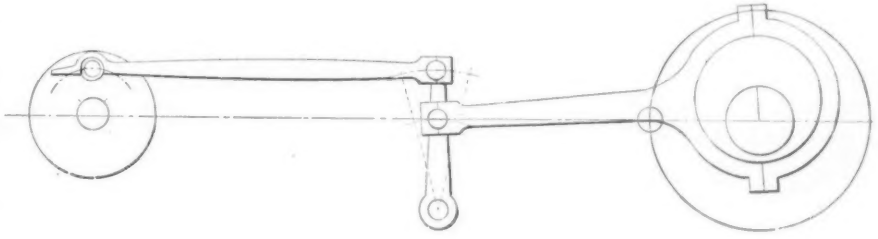


FIG. 3

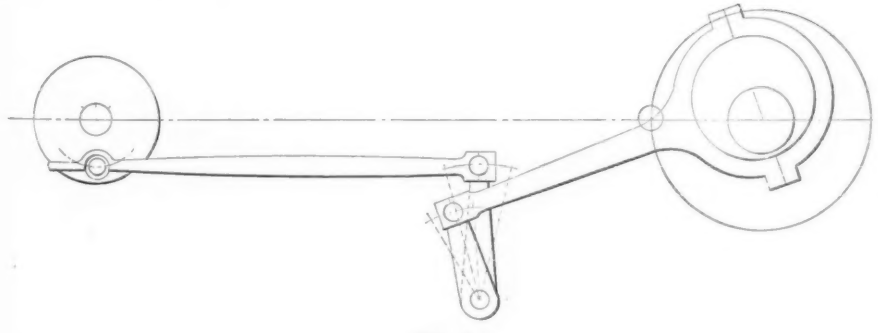


FIG. 4

W. C. TRACY.

Springfield, Mass.

To Clean a Water Gage Glass

The following is an easy way to clean a water-gage glass without removing it from the boiler. Pour some nitric or other acid into a glass of hot water so as to make about a 15 per cent. solution. Close the bottom water-gage valve and

blow out the glass by opening the pet cock. Then close the top valve and at the same time submerge the end of the pet cock in the glass of hot-water solution. A vacuum is at once created in the gage glass which causes the solution in the cup to rush in.

Keep the pet cock immersed and alternately open and close the top valve, thus expelling and drawing in the solution until all oil, grease and other matter adhering to the inside of the glass are removed. Then close the pet cock and open both water-gage valves. The result is a clean glass without risk of breakage and probable renewal of gaskets, which is frequently necessary when removing the glass for cleaning.

JOHN FRENCH.

Brooklyn, N. Y.

Suction Valve Caused Trouble

A compound steam pump was doing the pumping for a city water works, and as the whole town depended upon it while a duplicate was being repaired, it was necessary to keep it moving. The steam cylinders were so badly worn that there was no cushion on the steam heads, and to make matters worse one of the suction valves got stuck, causing the pump to work with a severe knock in one end.

As it was necessary to keep the pump running, the large valve *A*, Fig. 1, shown in the exhaust pipe, was used to a good

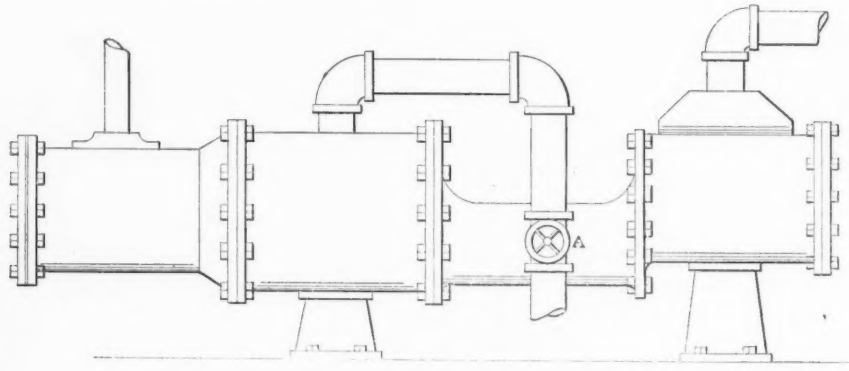


FIG. 1. SHOWING VALVE IN THE EXHAUST PIPE

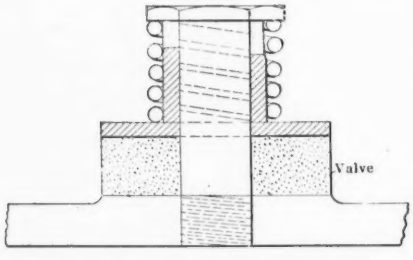


FIG. 2. SHOWING SPRING-PLATE CONSTRUCTION

advantage by closing it, thus giving the steam end of the pump a back pressure, which cushioned it and permitted us successfully to run it until repairs could be made. This increased our coal consumption, but operation was the main thing.

The reason the valve hung up was due to the spring plate becoming worn so that the spring could pass partially through the washer, and thus prevented the valve from closing properly. Had the spring plate been made as shown in Fig. 2, this trouble would not have occurred, and the cost would have been but slightly in excess of the ordinary plate.

C. R. MCGAHEY.

Lynchburg, Va.

Cutting in Boilers

At a plant where they have five 60-inch by 18-foot horizontal tubular boilers, connected to an 8-inch header by means of 6-inch risers, as shown in Fig. 1, every

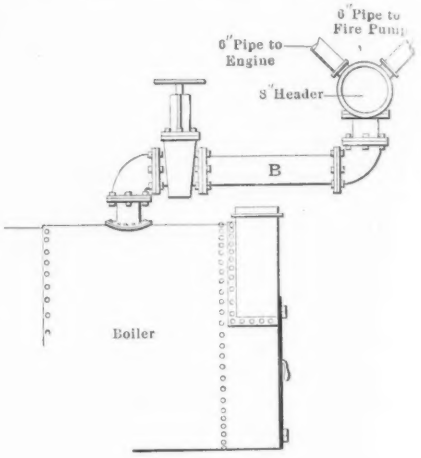


FIG. 1

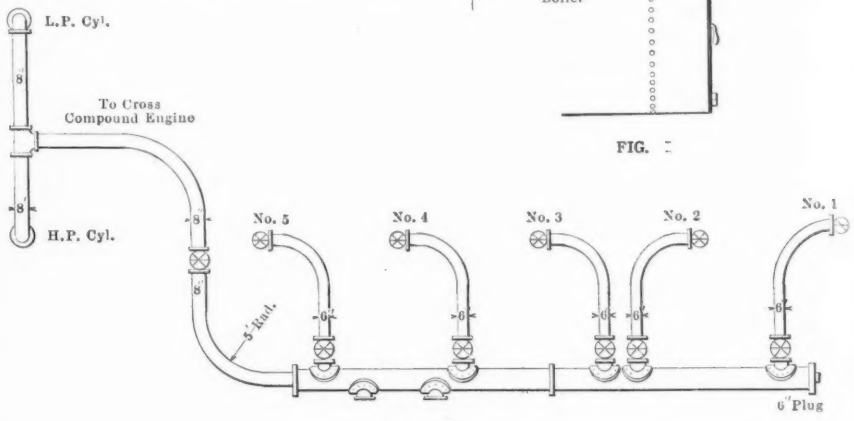


FIG. 2

he had no water in No. 5 boiler, that being the boiler nearest to the 7-inch outlet from the drum. Then the chief got mad and called the fireman names for letting the water out of the boiler.

We soon got straightened out and started up again under the same conditions, but before long the water supply dropped out of sight in No. 5 boiler while the chief was looking. He stopped the fire pump and then everything went all right. After apologizing to the fireman, he went to work and designed the piping shown in Fig. 2.

THOMAS SHEEHAN.

Pittsfield, Mass.

time a new fireman is employed the chief has to watch him closely when a boiler is to be cut in, so that the fireman will not follow his book learning and wait until the pressure is equal in the incoming boiler and the main. If the pressure in the boiler to be cut in was not 5 or 6 pounds less than on the main, the water that accumulated at *B* was carried over.

Everything went all right until one day a 20 and 36 by 36-inch engine had about all it could handle, when someone started the fire pump, then things "started to stop." The engine gave a few spasmodic kicks and stopped; then the condenser pump had a case of "frazzle" and, of course, the big engine got off the job. Then up popped the fireman, saying that

Indicator Reducing Motion

In the November 10 number, J. W. Grant describes an indicator reducing motion, which for small engines might be satisfactory at moderate speeds. Owing to the fact that the point to which the cord is attached swings in the arc of the circle, the diagram is somewhat distorted, and there will be a decided tendency for vibration of the cord, which will further distort the diagram at high speed.

At low speeds, the spring on the indicator will not require a great deal of tension in order to follow the stroke of the piston, but at high speeds considerable tension will be required. This tension will be thrown on a bell crank which, unless made exceedingly stiff and heavy, will bend, giving more distortion to the diagrams.

It would be comparatively easy to make this indicator motion transmit the power

in a straight line by making the end of the pointer elongated in the form of the arc of a circle about the pivot point.

HENRY D. JACKSON.

Boston, Mass.

Series Circuit Supplied from Constant Potential Circuit

I have read with a great deal of interest D. M. Grove's letter on page 836 of the November 17 issue, relating to a discussion between two electricians in regard to the value of the current in the primary circuit of a constant potential transformer, the secondary of which feeds a series circuit controlled by two constant-current regulators, when the load is decreased. The primary voltage is given as 1100 and the primary current as 20 amperes when the secondary load consists of 10 arc lamps and eighty 56-watt incandescent lamps.

Mr. Grove is of the opinion that the primary current ought to decrease if the 56-watt lamps are replaced by an equal number of 50-watt lamps since the load in the secondary circuit is decreased by approximately 5 per cent. The fact is, however, that the current in the primary circuit will remain constant if the constant-current regulators in the secondary circuit maintain the secondary current constant through variations in the load in circuit.

If the regulators fail to maintain the secondary current constant, the primary current will vary in direct proportion with the variations in the secondary current, since the transformer feeding the circuit is one designed for a constant ratio of primary to secondary voltage and of primary to secondary current, except insofar as the latter ratio is affected by the magnetizing current supplied by the primary circuit. Mr. Grove is correct in saying that the power required by the load on the secondary is decreased, but the apparent power, or the product of the secondary volts (as measured across the terminals of the transformer) and amperes remains constant and approximately equal to the product of the primary voltage and current.

What happens is this: Upon reducing the voltage required by the load, by substituting 50-watt lamps, or in any other way, the automatic regulators introduce more self-induction into the circuit to make up for the decrease in voltage caused by a change in the lamps. This causes the current in the circuit to change its phase relation with the voltage, and thereby reduces the power factor of the system, although the product of volts and amperes remains constant.

F. C. HELMS.

Schenectady, N. Y.

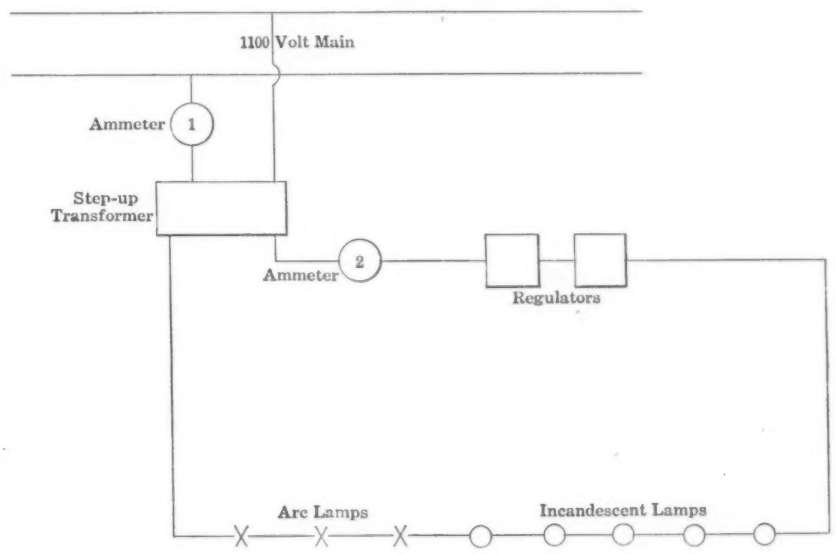
In the November 17 number, D. M. Grove had a note concerning the consumption of current in the electric circuit in the wiring diagram shown in the accompanying figure. The load in this circuit was supposed to be made up of 80 incandescent lamps connected in series and 10 arc lamps also connected in series, the arc group and the incandescents being likewise in series. The question was raised as to whether ammeter No. 1, in the primary circuit of the transformer shown in the diagram, would register a smaller current if in that part of the circuit operating incandescent lamps 56-watt carbon-filament lamps were replaced with 50-watt tungsten lamps. I wish to add a word to the discussion of this matter.

To keep the arc lamps in this circuit working properly it would doubtless be necessary to use tungsten lamps designed for the same current as that consumed by the carbon-filament lamps. With tungsten lamps designed for this current the regulators would have to be adjusted to give a voltage on the lamp load less than the voltage on this load before the carbon-filament lamps were taken out, since for a decrease in watts without a corresponding decrease in current there must be a reduction in volts. Ammeter No. 1 would register the same current as before the change of lamps; but the watts taken from the 1100-volt line would be less, because of a reduction in the power factor on the secondary side, and hence on the primary side also of the transformer. This statement assumes, and the assumption is doubtless correct, that the action of the regulators is similar to that of an ordinary choke coil, which is to vary the useful voltage by varying the inductance in the circuit. To lower the useful voltage the inductance would be increased, and consequently the power factor decreased. Moreover, the tungsten lamps, being designed for a lower voltage than the carbon-filament lamps, would have less resistance, and this would still further reduce the power factor.

If tungsten lamps made to run on the same voltage as that required by the carbon-filament lamps were used, there would, of course, be a decrease in the current taken by ammeter No. 1. But the operation of the arcs would probably not be as satisfactory as before the tungstens were put in.

J. E. LATTA.

Chapel Hill, N. C.



MR. GROVE'S WIRING DIAGRAM (REPRODUCED)

Valve Setting

I heartily agree with J. P. Allen in what he says on page 703 of the October 27 issue, regarding the articles on valve setting. Some time ago mechanical papers gave considerable space to the subject of engineers' examinations and the different license laws, both editorially and in the correspondence columns. I noticed that almost every applicant for a license in Massachusetts, who sent in the questions given him for publication, had been up against the problem of setting the valves of a Putnam engine.

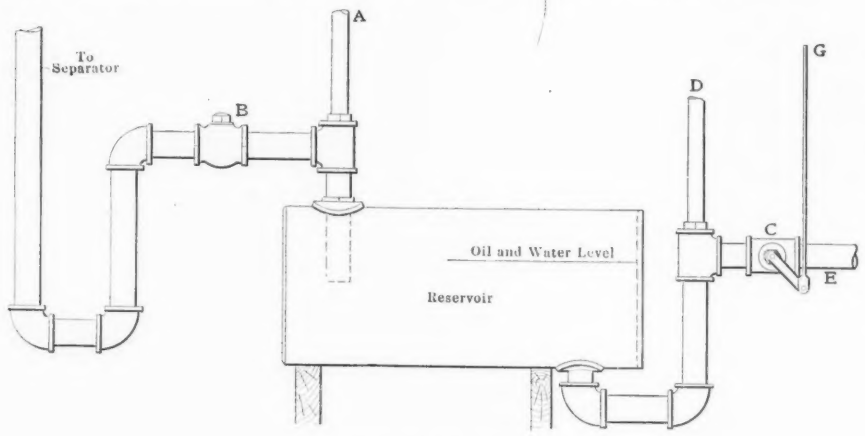
My experience has not been as varied as might be desired, for I have never seen a Putnam engine, and as it seems to be of such vital importance to the Massachusetts license inspectors, I can imagine what a poor show I would stand as an applicant for a license in that State. Therefore, when the article on the valve setting of the Putnam engine appeared in a recent issue I appreciated it very much, and put it aside for future reference. If there are any more out-of-date engine types which are likely to strike the fancy of some examining board, I hope POWER AND THE ENGINEER will publish a description of them.

R. CEDERBLOM.

Gary, Ind.

A Homemade Oil Separator

The accompanying illustration shows the use to which an ordinary closed vessel and a few fittings may be put. The pipe *A* may be used either for live steam or compressed air. The check valve B prevents a back flow of steam or air when emptying the tank. The pipe *E* connects with the sewer or drain, and the valve *C* is closed only while emptying the tank. The reach rod *G* may be extended or modified to suit conditions, and the delivery pipe *D* may be run to any suitable place or receptacle.



A HOMEMADE OIL SEPARATOR

It is evident that after reaching the reservoir the oil will rise to the surface of the water, and no flow will take place from the tank until the level of the pipe *E* is reached, when the water will be drawn off from the bottom of the tank, leaving the oil gradually to accumulate on the surface of the water. The contents of the tank may be discharged by simply closing the valve *C* and admitting steam or compressed air into the pipe *A*.

R. C. Hopkins.

Alliance, O.

Sparkless Commutation

In the November 10 number, on page 798, appears an article on "Sparkless Commutation." I submit the following from my experience with electrical machinery up to 1500 kilowatts capacity.

The causes of sparking may be classified as:

Armature carrying too much current.

Brushes not set at the neutral point.

Commutator rough, or having one or more flat bars; the eccentric having one or more high bars projecting above the others.

Brushes make poor contact with commutator.

Short-circuited coil in the armature.

Broken circuit in the armature.

Weak magnetic field.

As Mr. Saeger says, brush sparking is caused in most cases by rough brush and commutator surfaces. Rough brushes are the result of various causes, such as short-circuits, bad shots when throwing machines in parallel, especially rotary converters, picking up of copper particles, etc.

To provide the brushes with a clean, true bearing surface the writer has used the old method of leaving the brushes in the holders and drawing sandpaper over the commutator surface, thus cutting the brush down to a very true sufrace.

Rough commutator surfaces are the result of sparking, collection of carbonized oil, cutting of brushes carrying copper and other minor causes. To clean a commutator, Mr. Saeger advises the use of kerosene. I take exception to this, for the reason that it has been the experience of several operating engineers that in time the kerosene will cause the mica-insulating segments to deteriorate. The use of kerosene may be obviated by using a strip or two of fine sandpaper on a block of wood, applied by hand. The sandpapering may be followed with a very thin application of good dynamo oil free from dust. A suitable oil for this purpose will have a viscovity of from 4.5 to 6.5 at 70 degrees Fahrenheit.

The effect of oil on commutators has received considerable attention from investigators. Such men as Turner and Hobart state that the harmful effects of oil in saturating the mica insulation, and accumulating copper and carbon dust, is the real cause of breakdowns in 90 per cent. of all defective commutators. They also state that when really necessary to employ some commutator lubricant, vaseline or paraffin should be used. Further, they state that an oil spot here and there on the commutator will ultimately be seen to glow intermittently, and will eat its way deeper and deeper, in many cases without being discovered, and in process of time it will have covered enough area to set up a high resistance leak between two segments. This process continues until the coil breaks down through heating caused by the leak between segments. If the trouble has been located in time, it may sometimes be remedied by scraping out the injured insulation and then filling the cavity with some substance having heat-resisting qualities.

When a commutator has to be turned down, it is found that small particles of copper are bridged over the segments after the operation, and sometimes appear in the insulation between segments. For removing these particles the illustration shows a set of commutator knives which have been found very usfeul. They are made out of hacksaw blades, ground to the proper shape.

F. C. Loring.

Ithaca, N. Y.

Setting the Valves of the Cummer Engine

I like your idea of publishing contributions about old machinery, and as Mr. Allen, of Chicago, wants something on Cummer engines, I submit the following method of setting the valves which I have used for five years, while running a 14x30-inch Cummer engine. The directions are supplied by the Kilby Manufacturing Company, Cleveland, O., successors to the Cummer Engine Company.

To set the valve, first block up the governor weights in their outmost position to within ½ inch of the case, and then turn the governor until the main eccentric is in mid-position, or vertical, as shown at *A*, Fig. 1. Next bring the cutoff eccentric to the same position and fasten the clamp collar. Then adjust the eccentric rods until the rocker arm is plumb and the cutoff slide in mid-position. When this is accomplished, turn the governor one-fourth of a revolution, until the eccentrics are at their extreme travel, toward the cylinder, as shown at *B*, Fig. 1, and set the crank-end valves as shown in Fig. 2. Then turn the governor one-half of a revolution, i.e., bring the eccentrics to the other extreme, and set the head-end valves in the same manner.

FIG. 1

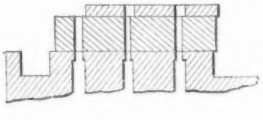


FIG. 2

Next, place the engine on the center and give the corresponding main valve the proper lead (1/32 to 1/16 inch) and drop in the intermediate gear. Then advance the engine until the crosshead has traveled about one-thirtieth of the stroke and loosen the clamp collar and advance the cutoff eccentric until the cutoff valve

on the steam side just closes the ports of the main valve; then re-fasten the clamp collar.

To set the exhaust valves, turn the engine to the point where compression is to begin, and let the corresponding valve just close.

CHARLES H. ALLEN.

Berea, O.

4000-Horsepower Engine Test at Brussels

We read in your issue of September 22 under the title, "The Dreadful Fate of the Steam Engine," some words relating to the results obtained at the Central Station at Brussels with our 4000-horsepower engine. It is regrettable, as you write, that the verification of the results would be difficult so long after the event. However, as it is a case of acceptance tests made under the supervision of the Association for the Surveillance of Steam Boilers, of Brussels, and in the presence of the representatives of the city, the results may be accepted without probability of grave error. Thinking that the detailed results of these tests would interest you, we send them herewith translated into English measures.

The engine is of the double-compound tandem type, driving a 3100-kilowatt three-phase alternator. The principal dimensions are as follows: Diameter of high-pressure cylinder, 34¼ inches; of low-pressure cylinder, 5 feet; stroke, 5 feet; ratio of

$$\frac{\textit{area high-pressure cylinder}}{\textit{area low-pressure cylinder}} = 2.97;$$

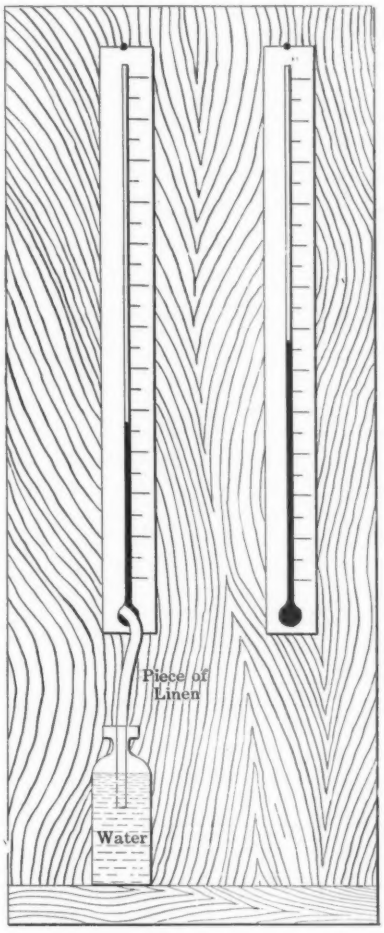
revolutions per minute, 83; piston speed in feet per second, 13.8. The results of the trials are shown in the table.

L'ADMINISTRATEUR DELEGUE.
VAN DEN KERCHOVE.

Brussels, Belgium.

A Practical Hygrometer

In many industries it is quite necessary to know the degree of humidity of the atmosphere in which certain work is carried on. A simple instrument which is accurate enough for all practical purposes may be made from two thermometers, calibrated so as to be identical. Mount them side by side on a board, having a ½-ounce bottle fastened to the board under one of them. Then take a piece of linen, say half an inch wide and 3 inches long, and wrap one end around the bulb of the thermometer above the bottle, allowing the remainder to hang in the bottle, which has been filled with water. The difference in temperature between the two thermometers shows the amount of moisture in the air. The dryer the day the greater the difference.



AN HYGROMETER

The theory of the instrument is as follows: On a dry day the atmosphere will take up more moisture from the cloth surrounding the thermometer bulb than it will on a damp day. Consequently, the greater the evaporation, the greater the amount of heat extracted from the mercury, and the greater the difference in thermometer readings. The difference will run from a few degrees to 20 degrees, depending on the locality.

J. J. O'BRIEN.

Buffalo, N. Y.

RESULTS OF TESTS ON A 4000-HORSEPOWER ENGINE AT CENTRAL ELECTRIC GENERATING STATION AT BRUSSELS.

	Ordinary Load.	Half Load.
Date	June 27, 1907	June 28, 1907
Hours Begin	9:22 a.m.	8:27 a.m.
Hours Finish	5:19 p.m.	4:27 p.m.
Boiler pressure Begin	145½ lb. per sq.in.	142.2 lb. per sq.in.
Boiler pressure Finish	145½ lb. per sq.in.	142.2 lb. per sq.in.
Mean pressure taken at steam dryer	136.5 lb.	137.9 lb.
Time of trial	7 h. 57 m.	8 hours
Mean speed number of revolutions per minute	84.324	84.056
Temperature of steam before entering engine, deg. F	519	498
Weight of steam consumed by the engine, lb	288.754	155.144
Water from receiver drain, lb	4757	6411
Receiver pressure above atmosphere Left hand, lb. per sq.in.	1.92	
Receiver pressure above atmosphere Right hd., lb. per sq.in.	2.98	3.7
Temperature of steam after low-press. cylinder. Left hand	121	122
Temperature of steam after low-press. cylinder. Right hd.	122	121
Corresponding absolute pressure Left hand	1.77 lb. per sq.in.	1.78 lb. per sq.in.
Corresponding absolute pressure Right hand	1.78 lb. per sq.in.	1.77 lb. per sq.in.
Mean vacuum indicated by vacuum meter, inches of mercury Left hand	27	26¾
Mean vacuum indicated by vacuum meter, inches of mercury Right hand	26½	26½
Mean vacuum calculated from diagrams (lb. per sq.in.) Left hand	11.37	12.75
Mean vacuum calculated from diagrams (lb. per sq.in.) Right hand	12.15	12.50
Vacuum in condenser, in. mercury	27½	27
Barometer pressure, in. mercury	30	30
Mean power of engine, indicated H.P.	3776.3	2019.9
Consumption of steam per indicated H.P. and hour	9.62 lb.	9.60 lb.
Consumption at 300 deg. C. = 572 deg. F	8.96 lb.	8.67 lb.

A Few Gas Engine Pointers

Do you wait in the morning until your engine has heated up before turning on the cooling water? Possibly you forget sometimes to turn the water on until it is so hot that it makes the lubricating oil smoke; and some time there will be a piece of cylinder or exhaust chamber lying in the corner of the engine room, and water over the rest of the room.

If you take your piston out to spread and clean the rings, don't use a wood ram to butt the piston into the cylinder, or you might crack the cylinder. In one I saw today the man had placed a liner about 1/32 inch under the rings, and when the piston jammed, he got a 4x4 timber to drive it in and got also a cracked cylinder.

If your exhaust pipe runs up from the cylinder without any exhaust pot, remember in cold weather to open the exhaust valve by hand before turning the engine over, or you may have to get a new rocker arm because water from the exhaust pipe froze the exhaust-valve stem, and when the engine was turned over something had to give, and the rocker arm was the weakest thing in line.

Did you know that asbestos was a kind of mineral wool and that it was not the best thing to insulate the "insulated" electrode in a make-and-break igniter?

In a hit-and-miss governor where chisel-edge pick blades are used, there will not be as many weak or after explosions if the edges are kept sharp so that if they engage at all they will hold for the entire stroke.

Would you believe that spiral gears on the two-to-one shaft could wear in time so as to alter the valves and ignition timing enough to increase the gas consumption? If you do, take notice whether your half-speed shaft has much play.

R. O. KLEPINGER.

Glen Karn, O.

Belts

By H. F. Hoffman

Having seen so many bad jobs on belts, I have come to the conclusion that a few pointers regarding them would do no harm.

The first thing necessary in caring for belts is to have proper tools for the work and, in the main, the style and kind shown in the attached drawings cannot be very much improved upon.

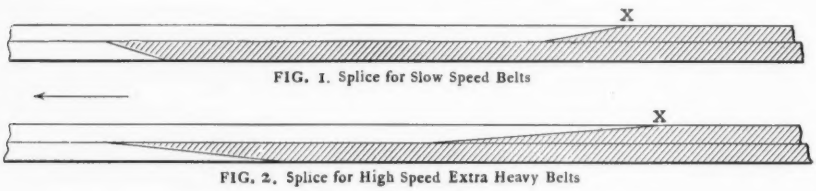


FIG. 1. Splice for Slow Speed Belts

FIG. 2. Splice for High Speed Extra Heavy Belts

What is generally called the dovetail joint is shown in Figs. 1 and 2, and is the one in general use on most all double-ply belts. The first is used mostly on slow-speed light belts, and the second on high-speed extra-heavy belting.

The splice opener is a very simple tool. I generally use a large screwdriver for this purpose, which answers very well. Another tool is the belt scraper for scraping the glue off of the joint after opening. It is made of a thin piece of steel about 18 gage, or a piece of an old handsaw will make a very good scraper. They should be about 4 inches square and fixed in a hardwood handle by sawing out about 2½ inches into the handle, and then driving the blade in, the saw cut being just a trifle thinner than the piece of steel. An exaggerated view of how the blade should look when properly finished is shown at *A*, Fig. 2. A small steel is also shown for sharpening the scraper after it is turned. At *C* is shown the "rig" for turning the edge of the scrapers. A large three-cornered file, about 10 inches long, having the teeth ground off very carefully and then nicely polished, is fastened to a piece of good belt leather by means of staples. The method employed in turning the edge of the scraper is as follows:

After the blade has been set firmly in the handle, grind the edge with a long taper of about ⅜ inch and grind from both sides. After obtaining a good, smooth edge, use an oil stone for a fine edge. The tool shown at *C* will do the work if handled properly. The thing to remember is that at no time during the turning of the scraper should the cutting edge bear upon the file. The handle of the scraper should be allowed to touch the file the first few strokes, gradually raising the handle and passing the blade from side to side, remembering to bear down on the blade. It will take about twenty minutes to turn a blade. The edge after it is turned should be at least 1/16 inch long and well hooked. The steel is to use on scrapers for sharpening them after they have been used. A beltmaker's heeler is shown at *B*, and should be used for paring down the laps after all glue has been removed, and then finished with a good, sharp scraper. Then the belt is ready for the glue, which should be well cooked and about the thickness of good cylinder oil. There are several good qualities of glue on the market, that can be bought in most any machinery-supply house.

A belt clamp is shown in Fig. 4, which should be made of good hardwood, maple being the best. It should have a thin piece of leather glued to the fitting part,

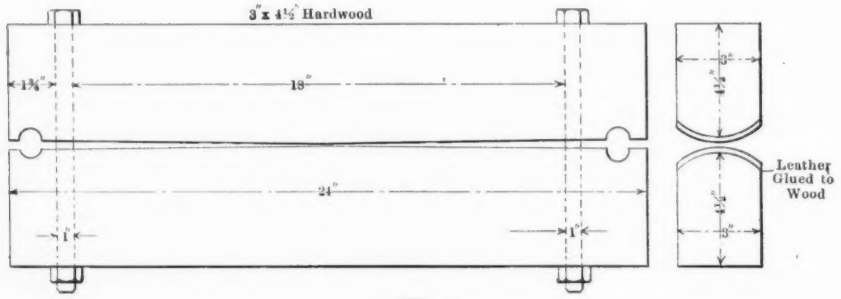


FIG. 4

or gripping the belt so as to prevent slipping. The side rods should be made of ¾-inch iron and have right- and left-hand threads turned on them with a hexagon-shaped center for a wrench, to be used in tightening up equally on both sides of clamps.

Splicing a Belt on Pulleys

The proper mode of procedure in splicing a belt on the pulleys is as follows:

First decide on where the belt is to be opened, always opening the worst place in the belt, placing this point in the most convenient place possible, and then put the clamps on. All of the shortening must be done on the first end point on account of the ease with which the new lap can be made. Should the last end point be shortened it would cause a lot of extra work, as there would be two outside ends to scarf. The first clamp having the center mark coinciding with the center of the belt should be very tight, as in case it should slip when the strain is put on, it will slip in the middle of the belt and may not slip on the edges at all, and should it be glued in this condition, the chances are very much in favor of the outside edges giving way on a heavy load, due to the middle being too long. After the clamp has tightened the belt the desired amount, open the joint, Fig. 2, at both ends of the splice before the middle is touched. After opening the joint in the belt, tighten upon the rods until the belt is the proper tension. Then put the splicing boards under the joint and proceed to lay off the laps. To do this, square the two thin points and put the first end point in between them. Of course the first end point will have to be cut off before the belt will be down properly. The amount to cut off this

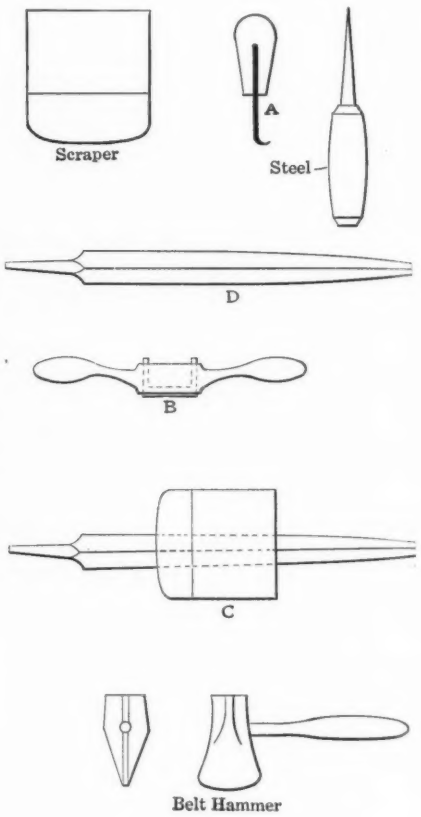


FIG. 3

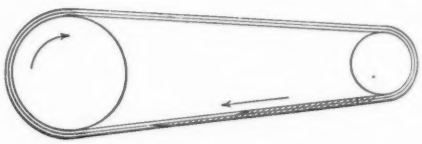


FIG. 5

end will be just as much as the belt has been shortened between the clamps.

Next, using a square, mark across the belt, using the end of the thin point for obtaining the length, and without moving the belt, make a mark on its edge showing just where the lower thin point came on the bottom; then scarf down the top of the first end point, letting the scarf be about 4 inches long on an 18-inch belt, making the inclined plane perfectly flat. Next clean the glue from off the inside of the first end lap, up to where it enters the last end, and make the other scarf. Next clean all the glue off the last end lap and bring it down to the proper thickness with the heeler and scrapers to a knife edge.

After the thin points are properly finished, lay the whole splice back on the splicing board just as it will be when glued and do any fitting that may be necessary. Be sure to get it thin enough so it will not make a hammering noise when going over the pulleys. Do not try to glue more than 6 inches at one time. Use a heavy brush about 2 inches in diameter, and have the glue well done. When spreading the glue, work fast to get all the glue off the brush possible and get the rest on the belt at once; make two or three fast strokes across the belt and close down the splice and rub with the handle of the scraper for about two minutes. Then have an assistant raise the point up until the glue can be seen, and then repeat the former process, with the exception that you need not apply the glue to both sides of the lap as in the first case. When the laps are all glued, the joint is ready to rub, after which hammer lightly the entire splice and let it set for from four to six hours.

In case of an oil-soaked belt, secure a good gasolene blow torch and use after the splice has been completed except at the thin points. When the splice has been made and the old glue has been removed, direct the flame directly on the leather and move it over all the surface of splice until it has become thoroughly heated; never allow the flame to be directed at any point on the lap to make the oil boil; if you do the belt will burn. Continue to move the flame over the belt until the leather is so hot that the hand can scarcely be held on it, and with one of the scrapers, scrape the oil off as the heat brings it to the surface. It will require at least six hours' good, hard work to remove the oil from a well soaked 36-inch belt. Fig. 5 shows the direction in which a splice should be run so if anything should come in contact with the belt it would have a tendency to rub the points of the lap down rather than raise them up, as would be the case if run in the opposite direction.

Air-pump displacement should be 1/75 of the low-pressure piston displacement on a compound engine.

Common Sense Science

By Charles S. Palmer

The air is so full of articles on industrial education nowadays that one can hardly swing a pen without hitting some writer on the subject who is anxious to tell us how they do things abroad; and somehow they have found out that the basis for all natural education is a training in these three things: first, the native language; second, mathematics enough to figure the ways and means of common life; and, third, drawing. Now this is good sense, but there is another set of studies which rank high in their easy and natural use and necessity, and which come close to language, mathematics, and drawing; the subjects are the natural sciences in general, and physics and chemistry in particular.

There is no reason why very young people should not learn of the common machines, the common forces, and the common substances. It is not necessary that they should know all that the advanced college course can tell about these, but it would be worth much to have young folks started right. The trouble is that most of our schools are fitting for the next higher grades; and if the printed course says that certain studies must come later, later they come; and as a rule, physics and chemistry are not taught as though they could be used from the first day, but as though they were parts of a long theory which must be mastered before there comes any suggestion as to the use to which these live and fascinating inquiries may be put, for the correct study of any science is to treat it as though it were a big interrogation mark. Education does not consist of information, but education is showing the boy or the girl how to get and use his information for himself.

The other day I visited a high school not a thousand miles from Boston, with the presuming intention of suggesting to the teacher of physics that we teachers should all use more natural methods in our teaching. I waited patiently until recitation was finished for the day. The teacher had been trying to show the boys something about the hydraulic press, "because, you know, it illustrates Pascal's law and doesn't really take any knowledge of mechanics;" as though any machine were able to do its work without showing its special part of mechanics! Now this particular machine had not been behaving well. In fact it had developed certain original views of its own; it had leaked, and a large and active pool of oil had run out on the lecture table, where it was illustrating some of the laws of liquids in its own way. Now such accidents as a leaky valve or piston are common affairs in the practical shop; but for these breaches of mechanical etiquette to occur on the well-dressed conventional lecture table is little short of personal discourtesy. I looked at that dirty press askance, and tried to bring the teacher around to the better ways of treating his subject. At first he said: "O, sir, but we are doing all that; there is really nothing new in what you propose." But, as I enlarged on the plan to start the student with the use of machines, just as though the laboratory were not a mere play house, but a practical shop, he timidly confessed: "O, but we cannot possibly do that."

Then I tried to make that teacher see the simplicity of the scheme which is needed; and naturally, some reference was made to the leaky press still mournfully adorning the lecture table. In fact, the word "opportunity" was used in referring to it. Now the teacher took offense at this allusion to his accident, for accidents will happen. It took several minutes for me to convince him that I meant no insult, but that I was sincere in asserting that the leaky mishap was really his opportunity. After some blind questions, he frankly asked me what I meant by that breakdown being his "opportunity." So I told him. I suggested that then and there, before the class, he should have taken off his coat, rolled up his sleeves, called for one or two volunteers and made that machine do its work in a clean and sensible manner. Of course, the trouble was in the packing of some valve or piston, and the teacher asked me incredulously whether I knew how to pack valves. I told him frankly that I did not know how to pack all kinds of valve and joint, though I had fixed some of them, but that the making of that one right was, in my judgment, the question of the hour for him. I suggested that if the difficulties of this particular packing transcended his abilities, he should call on the engineer of the building in the basement, who could probably do the trick; but do it some way I would, for that machine must be made to work right before that class. It was not fair to the machine, it was not fair to the class, to let the experiment go with every appearance of a bungling failure, when the press would be glad to do its work if it had half a chance. But the teacher shook his head: "No, I have no time; we are short now, and if I should stop to fix that press it would perhaps take the time of half a dozen exercises; and what would the boys do if they were short several exercises next June before the entrance requirements for Harvard and Tech?"

Now this actual observation by the writer occurred only a few weeks ago, and in one of the most noted schools of New England. It is probably a fair sample of what is being palmed off on a long-suffering public as "education;" education in natural science! Of course it is easy to say that the teacher should have known how to take his machine to pieces and re-

assemble it in working order. There are many different kinds of machine in the high-school equipment in physics and there are also many other high schools and many teachers, but the trouble is with the system which requires half knowledge of many things, rather than perfect familiarity with a few fundamentals. No wonder that the teaching of natural science is backward, and still less wonder that this kind of "manual training" should not contribute actively to industrial education.

But there is one practical lesson to which I wish to draw attention. It is the wisdom of knowing something about packing all kinds of joint. Probably there is no one mechanical accomplishment more generally used or more necessary than this one of packing moving friction surfaces so that they shall be easy in movement and yet tight against leaks, and yet it is hardly mentioned in the standard textbooks of physics. Take a look at the advertising pages of any standard publication on power or engineering. The variety and perfection of the various kinds of packing are simply monumental, and interesting beyond the passing moment. If there were no other record left for later generations to use in estimating and reconstructing the mode and the degree of our present mechanical development, these advertisements of packing would tell whole cyclopedias about our boilers, engines, valves, pistons and friction boxes of all kinds. Indeed, there is no more fascinating part of a good journal on practical mechanics than these advertising pages. Upon taking up a copy of one of the leading journals on the practical application of power, I find that there are some 15 or 20 different kinds of packing, oil and grease, not to mention the scores of related devices in the way of tight joints, oil separators and the like. Manifestly this phase of machinery is one of the most important for the economical and reliable handling of the various producers and distributors of energy, and yet one would hardly guess it from the hackneyed indifference thereto shown by the school books. One would not believe that such a condition of neglect could exist in this age of supposed attention to the best interests of what our boys should know; and more than that, what they should know how to use.

I do not wish to sail under false colors, and will frankly confess that I am not a practical engineer, but I have seen some defects in the educational system. Is it not a fair question to ask whether the complete ignoring of all that concerns, not packing merely, but the other related subjects of friction and of power drive by bolt or gear or by electricity, and their costs, is justifiable? What kind of a notion must the student carry away with him of the machines in the school laboratory, which may or may not work? What great gap must exist in the student's notion between pretty and clean machines which may be fixed up for him before the recitation begins, or which may break down hopelessly in his sight, and the machines of the railroad, factory or central station which behave badly at times, but which must be made to go? Such accidents as that which came to the hydraulic press of this story are the common thing in real life, and it is absolutely necessary that the man behind the machine must know how to meet the casual emergency. Why not the same common sense meeting of daily troubles in the schools?

Another case in this same line came up recently in a school near Boston, where "sloyd" was "taught." But when the knives and chisels got dull—and such things will happen—the students were not taught how to sharpen them. Yet this sort of thing passes for education. Is it any wonder that the public is beginning to ask why the manual-training idea does not give better results? Now it is something to have any kind of laboratory work, where the student can use his eyes and hands together; this, bad as it may be, is better than mere bookwork, and especially when treating subjects which cannot be studied except by seeing and handling them; but we want the real thing. Perhaps the day is not far distant when the first question asked the prospective candidate for teaching physics will not be: "From what college did you graduate?" but "In what machine shop did you work, and how long?" The University of Hardknocks is still worth attending, and the diploma signed by an oil can and a monkey wrench is still good for its face value.

Surface condensers require 1½ to 2 square feet of cooling surface per engine horsepower.

Remarkable Power Plants at Mount Ranier

By George F. Stratton

The highest mountain in the United States and one of the great mountain peaks of the world is Mount Ranier, which lies about 50 miles southeast of Seattle. It covers 200 square miles and

FIG. 1. THE GLACIERS AT MOUNT RANIER

rises 14,500 feet above the waters of Puget sound. Above an elevation of 5000 feet it is covered with glaciers which continually move slowly down the mountain sides, filling the valleys about the base to a depth of hundreds of feet.

As these glaciers gradually settle below the 5000-foot level they melt, and the resultant streams are the sources of some of the greatest and steadiest water-power developments on the Pacific coast. The most notable of these is upon the Puyallup river, which, although called a river, is only a mountain torrent. This stream is diverted far up the mountain side into a timber flume 8 feet wide and 5 deep, which conducts the water for 10 miles to a reservoir situated on a high plateau. It

FIG. 2. PUYALLUP POWER PLANT

is then discharged through steel pipes down a steep hillside 872 feet in depth into the water wheels operating electric generators of 40,500 horsepower.

The situation of the power house is wildly picturesque. For miles in either direction extends some of the heaviest forest growth of the Pacific slope. Except for the construction of the power house and flumes, the primeval forest is untouched—a salvation due to the roughness of the surrounding country and the consequent difficulty in taking out logs. The power house atones for its uninteresting ugliness of design by its astounding interest of achievement. On the one side are the black, steel supply pipes, 4 feet in diameter and nearly 1000 feet in length lying in sinuous curves and bends down the face of the steep, rocky hillsides. On the other side of the house are the outlets, discharging great columns of water as big as barrels, in rushing, tearing, horizontal volleys, for 200 feet across the tailrace. In no power house in the country is the water discharge shown with such startling vividness, such evidence of force and power, as at the Puyallup plant.

FIG. 3. PENSTOCKS AT PUYALLUP

This power is transmitted to Seattle, 48 miles distant, and to Tacoma, 32 miles away. It is operating trolley cars at Seattle, carrying 40 millions of passengers yearly, and suburban lines to Renton and Tacoma. It grinds many thousand bushels of grain, daily, runs smelters, iron mills and numerous small factories, besides furnishing light for six towns.

At another of the Mount Ranier streams is the most extraordinary power plant in the country, and probably in the world. At one point in its rush down the slopes, this stream plunges over a solid, granite ledge 70 feet in hight. On the bank above the falls may be seen a little rough-stone 10x12-foot building, and entering that the visitor descends a shaft 60 feet in depth. At the bottom a passage leads beneath the river, and proceeding about 20 yards, enters a large cavern which has been hewn out of that granite ledge directly under the bed of the raging torrent. In this cavern are set the turbines and electric generators. The intake pipe leads from the roof of the cavern up into the bottom of the river bed. The outlet pipe discharges directly behind the base of the falls. From the little stone house wires stretch away through the grim foot-hills and thick forest growths to Seattle, conducting 6000 horsepower for service there.

FIG. 4. TRANSMISSION LINE TO SEATTLE

Another strange power plant, but without picturesque features of the Mount Ranier plants, may be found on the Patapsco river, in Maryland—a stream without any rushing torrent or high falls, but with a great volume of water. A huge, hollow dam has been built at one point and all the machinery has been installed inside of that dam instead of in the customary power house. Water is taken from the upper side and after passing through the wheels is discharged at the lower foot of the dam. A thin sheet of water may be usually seen gliding over the spillway, but there is no sight or sound of machinery—simply the wires leading across country to a neighboring city, and conveying the 1600 horsepower which is developed.

Cost of Producer Gas

By B. M. Baxter

In the issue of Power and the Engineer, of November 3, 1908, in the report of the meeting of the Gas Power Section of the A. S. M. E., is a digest of a paper by Elbert A. Harvey, on "Bituminous Producer Plants." On looking over the portions of this paper devoted to the plant of the Garford Company, Elyria, Ohio, one is struck by the inordinately high cost of fuel producer gas, figured on the basis of an equivalent of 1000 feet of natural gas. A little analysis of the figures given brings to light some very peculiar results.

First, with reference to the amount of fuel required for operation of the engines: "Coal burned in producer for gas for engines 2.18 pounds per kilowatt-hour at switchboard." Figuring this on the basis of coal per brake horsepower-hour we get about the following: At 2.18 pounds per kilowatt-hour at the switchboard,

$$2.18 \times 0.746 = 1.626$$

pounds per electrical horsepower-hour at the switchboard. Allowing a generator efficiency of 92 per cent.,

$$1.626 \times 0.92 = 1.496$$

pounds per brake horsepower-hour.

If the engine uses 10,000 B.t.u. per brake horsepower-hour, a figure attainable in good practice, then the thermal engine efficiency would be 25.45 per cent. As gas engines have operated under test at considerably higher efficiencies than this, it may be considered fairly conservative. Taking the heat value of the coal at 13,500 B.t.u., as stated by Mr. Harvey, the B.t.u. input of the producer per brake horsepour-hour of output would be

$$1.496 \times 13{,}500 = 20{,}200 \ B.t.u.$$

With 10,000 B.t.u. used by the engine, the efficiency of the producer plant would

be 49.5 per cent. This will be recognized as extremely poor producer practice; the producer should deliver 70 to 75 per cent. of the heat value in the coal in the form of cool, clean gas.

Or, figuring it another way, on the basis of plant efficiency, coal to brake horsepower, we would have

$$\frac{2545}{20{,}200} = 12.6 \textit{ per cent.}$$

If the engine efficiency were only 20 per cent., this would make the producer efficiency

$$\frac{12.6}{20} = 63$$

per cent., which is still low. Or, if the producer be up to standard, then the engine efficiency would be

$$\frac{12.6}{75} = 16.8$$

per cent., which is very poor for a gas engine of any size and pretension to good operation.

Turning to the fuel-gas side of the plant we have 85 pounds coal to produce the equivalent of 1000 feet of natural gas. Taking the heat value of natural gas as 1000 B.t.u., we find for the producer efficiency: 85 pounds of coal at 13,500 B.t.u. = 1,148,000 B.t.u.; 1000 feet of natural gas at 1000 B.t.u. = 1,000,000 B.t.u.; efficiency of producer =

$$\frac{1{,}000{,}000}{1{,}148{,}000} = 87.2$$

per cent. This is remarkably high for any producer, and would only be realized if the gas were burned close to the producer, raw, and without the loss of its sensible heat. After the heat loss necessary because of extraction of tar and cooling of gas, such an efficiency is absurd. It is evident that the operating figures of the plant as given cannot be accurate, the figures being apparently intended to show a high efficiency for the gas as applied to furnace work; and yet there is given the abnormally high cost of 58½ cents per equivalent of 1000 feet of natural gas.

Taking up for investigation the next items in the tabulation one finds:

	Pounds.
Steam supplied by 80 lb. of tar	940
Steam supplied by 75 lb. of coal gasified	492
Steam supplied by 75 lb. of coal burned under boiler	440

The above may warrant a little curiosity as to the boiler efficiencies obtained:

Water evaporated per lb. tar =

$$\frac{940}{80} = 11.75 \text{ pounds.}$$

Water evaporated per lb. coal gasified =

$$\frac{492}{75} = 6.57 \text{ pounds.}$$

Water evaporated per lb. coal fired under boiler =

$$\frac{440}{75} = 5.87 \text{ pounds.}$$

One is struck here by the widely different rates of evaporation. Assume, so as to get a basis of comparison, that the boiler carries 100 pounds steam pressure, and assume for simplicity that the steam delivered is entirely dry, taking the feedwater temperature at 150 degrees, as it might be if the gas-engine jacket water were used for feed, no feed heater proper being used, then with these assumptions we would have: B.t.u. added per pound of steam = 1067, about. Assuming a heat value of tar at, roughly, 15,500 B.t.u. per pound, we have:

Boiler efficiency tar firing —

$$\frac{1067 \times 11.75}{15{,}500} = 81.0\%, \text{ about.}$$

Boiler efficiency coal firing —

$$\frac{1067 \times 5.87}{13{,}500} = 46.3\%, \text{ about.}$$

Boiler efficiency gas firing —

$$\frac{1067 \times 6.57}{13{,}500} = 51.8\%, \text{ about.}$$

It would be interesting to know how this curious condition of affairs is accounted for, all the above classes of fuel being used under the same boiler.

Costs of Operation

Assuming that the coal costs are correctly proportioned, in spite of the curious producer efficiencies obtained in the preceding figures, we find under "cost of equivalent 12,000,000 feet of natural gas per year," "labor, $1870." Looking in the detailed figures in the column above we find that this is the *total* labor cost of operating the gas plant. When we consider that the greater part of the gas is used for power, it is manifestly unfair to charge the whole cost of operation of the gas plant against the fuel gas.

Splitting this cost up proportionately to the consumption of coal for each purpose, as stated under the heading "coal," we would have: Cost of labor =

$$\frac{340}{723} \times 1870 = \$880,$$

the 340 being coal consumed per hour for gas, as stated, and 723 being coal consumed per hour, total.

Water

There is charged $540 for water against the fuel-gas account, and $504 against power gas. As the total water cost is $1044 in detailed figures, it is apparent that the *total* water bill has been split between the two accounts. But this is not rational, because the greatest item of expense is for jacket water. It is not clear why part of the expense for jacket water should be charged against the producer plant.

Taking only water used for gas making and purifying we have:

	Gallons.
Washer	3,000,000
Cooler	5,250,000
Boiler	750,000
Total (not including engine water),	9,000,000

Dividing up this water account proportionately to coal consumption for each purpose, as explained, we have

$$9{,}000{,}000 \times \frac{340}{723} = 4{,}230{,}000$$

gallons chargeable to fuel-gas account. At 6 cents per 1000 gallons, this gives

$$\$0.06 \times 4230 = \$253$$

as the cost of water, instead of $540.

Overhead Charges

The total plant cost of $51,620 is divided into 37½ per cent. for the gas plant and 62½ per cent. for the engine plant. This makes the cost of the gas plant about $19,370, and 15 per cent. of this is $2900. That is, the total overhead charge for the gas plant is charged against the fuel-gas account, and none against the power account. This is a manifest absurdity, as less than half the capacity of the plant is used for fuel gas.

Dividing this up as before gives

$$2900 \times \frac{340}{723} = \$1227$$

overhead charges chargeable to the fuel-gas account, in place of $2900. Summarizing, we have:

Coal (probably not correct; see figures on producer efficiency)	$1411
Labor	880
Water	254
Miscellaneous	100
Repairs	200
Overhead charges, interest, depreciation, etc.	1227
Total, cost of equivalent of 12,000,000 feet natural gas per year	$4073

The cost per equivalent of 1000 feet of natural gas =

$$\frac{\$4073}{12{,}000} = \$0.3394,$$

or about 34 cents, instead of 58½ cents.

The given cost of the gas plant, $19,370, probably includes distributing mains, valves, burners, etc., as it would be very high for a gas plant of this size without the fittings.

To get some idea of the cost of gas, delivered clean from the scrubber, assume the cost of a 750 horsepower gas-generating and cleaning plant as $13,500. If $\frac{340}{123}$ of the capacity of the plant is used for fuel gas, then the investment for fuel gas and depreciation, etc., would be

$$\frac{340}{723} \times 13{,}500 \times 0.15 = \$952.$$

Then

Cost of coal	$1411
Labor	880
Water	254
Miscellaneous	100
Repairs	200
Overhead	952
Total	$3797

$$\frac{3797.00}{12{,}000\ M} = 31.65$$

cents per equivalent thousand of natural gas. This cost is still higher than it should be, and could probably be accounted for by the supposition that the gas plant was not operating up to its rated capacity. If this were not the case, it would be a doubtful investment, except as insurance against shutdown from failure of natural-gas supply, to put in a producer plant, since natural gas can be purchased, even in small quantities for domestic service, in this territory at the rate of 30 cents per thousand, while large users in the city of Cleveland get natural gas, though subject to shut off at any time, at 10 cents, or lower.

Steam Pipe Connections

By Fred Dubell

Steam piping is one of the important parts of a steam plant, and its proper arrangement and construction are of great consequence. Poorly arranged piping may destroy the economy of the most economical engine, may occasion serious wear, or perhaps may be the cause of a badly wrecked cylinder. As these results are commonly believed by the user to be the fault of the engine, it is of the greatest importance to the builder that the cause be removed, and of equal importance to the owner on account of the loss of fuel, expenses for repairs and perhaps loss of time. As an engineer and erector of 30 years' experience, the writer feels safe in saying that steam piping poorly designed has caused more trouble and expense than all other difficulties put together.

Large Pipes and Easy Bends

First of all, economy demands that the pipe and valves shall be of sufficient size to carry practically boiler pressure to the engine. With steam at 75 to 100 pounds pressure, the velocity of flow per second should not exceed 80 feet if the pipe is reasonably short and straight, or 65 to 70 feet if the pipe is long or has many bends, and the size required for this velocity should commence at the opening from the boiler and continue to the engine. Straightway valves are preferable, also long-sweep elbows, and tees are to be avoided if possible; a one-eighth bend and a Y is a more profitable investment. A tee will inevitably cause some loss of pressure because of the energy absorbed in accomplishing the abrupt change of direction in the flow of steam. The loss in a short elbow is less than with the tee, but the long-sweep elbow and the one-eighth bend with a Y give a long curve and gradually change the direction of flow without noticeable drop of pressure. Through ignorance or a desire to save on initial cost, or because certain piping is already in place, either a smaller size of pipe is used than the engine calls for, or the size at the engine is used where the engine is a long distance from the boiler or where there are many bends, or both. Naturally there results a loss of pressure and a consequent loss of economy in the use of the steam which would pay the additional cost of the larger piping possibly several times in the course of a single year. Pipe, then, of proper size and easy bends is essential to economy, and if two or more boilers are to be used for one engine, the pipe for each to the common receiver should be ample for its capacity and as direct as possible, or if more than one engine is to be supplied, the receiver or header should be large enough to supply all demands, and the connection such as to avoid, if possible, abrupt turns. In taking indicator cards just above an engine equipped with a small steam pipe, the pressure was reduced nearly 10 pounds when the engine began to take steam, rising again after the point of cutoff, this being a case of serious and ceaseless waste.

Prevent Radiation

For economy, the steam pipe should also be carefully protected by some good nonconducting covering, either in plaster or in sectional form, taking care in the latter that no air leaks are allowed which permit a circulation of air between the covering and the pipe. It has been repeatedly claimed by steam users that in a boiler house or other warm room no covering is needed, but seldom is the temperature in such rooms over 100 degrees, usually being much less, while steam at 80 to 100 pounds gage pressure has from 324 to 338 degrees of heat. This difference in temperature would result in considerable condensation and consequent loss of fuel. In every automatic-cutoff engine there is large internal condensation occasioned by the difference between initial and final temperatures, but condensation in the steam pipe, when uncovered or poorly covered, increases to a great extent the cylinder condensation because of the moisture already entrained in the steam. When it is considered that at 80 pounds pressure every cubic inch of water represents 285 cubic inches of steam and that the 886 degrees of heat which were needed to turn that water into steam are lost, the value of a good pipe protection will be realized. Undue condensation has also the effect of reducing the initial pressure in the cylinder, and adding this drop to that occasioned by too small a pipe, serious loss may arise.

As to wear, water in steam will cut the edges of the valves and ports, causing leakage and improper distribution of the steam with consequent strain upon the working parts. Sometimes water will also neutralize the action of the oil in the cylinder and permit surface cutting. Hence the importance of pipes sufficient in size and so carefully protected against radiation of heat as to permit the least possible condensation and the least wear from this cause.

Steam Pipe Should Drop toward Boiler

The possibility of wrecking the engine is perhaps of more importance still, as a broken engine means not only the cost of repairs, but usually a much greater loss through the stoppage of production. The water of condensation entrained with the steam and carried with it into and out of the cylinder, very seldom is sufficient to cause breakage, though it may occasion disagreeable slapping in the cylinder and loosening of connecting-rod boxes, but when pockets are allowed in the pipe where water may gradually collect and be carried over in volume with the steam into the cylinder, then injury to the engine is only a question of time. Engines are not made to be run with water, and though valves may be made to lift from their seats, or relief valves may be installed, any considerable amount of water so carried into a modern engine with small clearances will inevitably result in a broken crank, broken cylinder, bent connecting rod, or all these and sometimes more. Improper arrangement of exhaust pipes will sometimes do the same thing, but that is beyond the scope of this writing.

Good design calls for a steam pipe sloping back all the way from the engine to the boiler with enough pitch to permit the water of condensation to run back to the boiler against the resistance of the outflowing steam. Otherwise, there should be such a slope as far as may be readily possible, and then a constant drop all the way to the engine without any rises after beginning to drop unless the pockets so made are carefully trapped so that they are automatically and surely drained. Steamfitters have insisted that such a pocket, once drained when the engine is started, would be kept clear by the velocity of the passing steam so long as the engine is running. A long experience with various engines and more varied steam piping has conclusively proved the contrary.

About 15 years ago the writer installed an engine in a plant and left it running satisfactorily, which it continued to do for about three years, when the crank pin broke. In being sent to replace the pin and report the cause of the accident, the following conditions were found: The plant had been remodeled and the piping changed. It rose from the boiler about 3 feet, passed into the engine room horizontally for 15 feet, then diagonally across the room about 50 feet, with an apparent rise of at least 3 feet in that distance, and then dropped vertically about 6 feet to the engine. The apparent rise of 3 feet was so marked that no special attention had been given the 50-foot length of pipe until it was noticed

that the two ends on opposite sides of the room were exactly level with the wall plate upon which the roof rested. The apparent rise of 3 feet was an optical illusion occasioned by the diagonal passage of the pipe about 6 feet above the line of vision. A level showed that the pipe was the same hight from the floor at its two ends and sagged its full diameter of 4 inches at the center. This, of course, permitted water gradually to accumulate until the opening at the lowest point was too small to allow enough steam to pass for the need of the engine, when, like the action of the wind upon the surface of a pond, the steam raised a ripple on the water, making the space for its passage still smaller, then a larger ripple and another until the opening was entirely closed and the water all of a sudden carried into the engine cylinder. This is what broke the crank pin. The pipe was raised 5 inches at this point and supported, and there has been no more trouble from water.

Faults in Engine Design

By C. R. McGahey

Fig. 1 shows the construction and dimensions of a crank pin. The 1¼-inch pin passing through the crank pin is of soft steel. I have seen some of these pins break, as shown by the line *E*. One instance was with a high-speed engine running at something under 300 revolutions per minute, the crack being caused by water. The steel pin in the center did not prevent the pin from cracking; but, possibly, had it not been for it the crank pin would have gone entirely free from the disk.

How should a cast-iron pin be made?

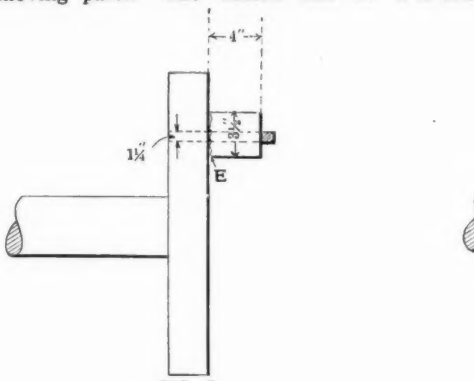


FIG. 1

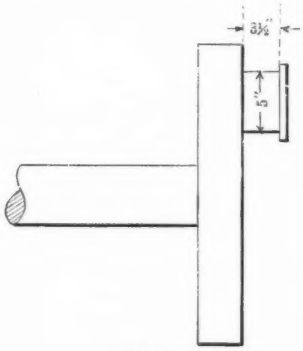


FIG. 2

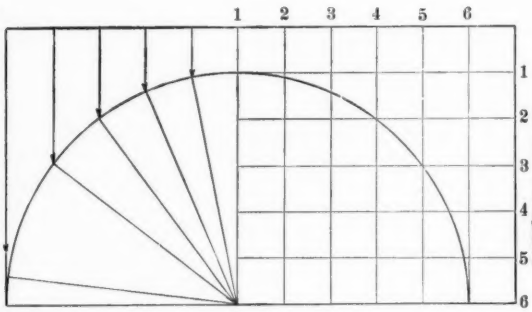


FIG. 3

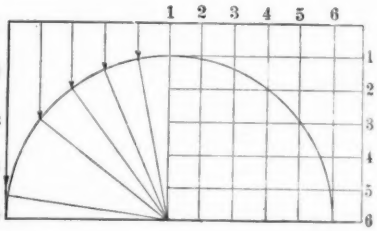


FIG. 4

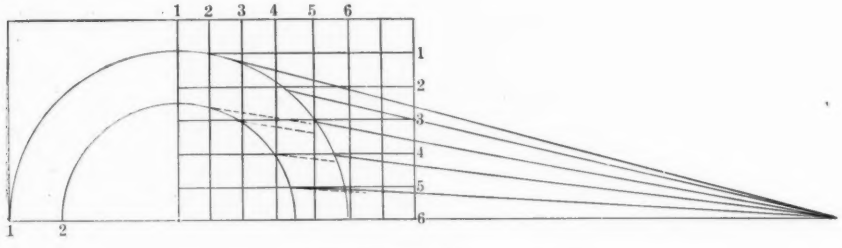


FIG. 5

The pin in Fig. 1 has a surface area of approximately 44 square inches. Assume that there is a 12-inch piston behind it, with an initial pressure of 135 pounds. As the pin has a surface area of 44 inches, and only half, or less, is in direct contact with the pressure from the piston, we would have a 12-inch piston head with an area of 113 square inches which, multiplied by the initial pressure, equals 15,255 pounds pressure on the one side of this crank pin. With an area of less than 22 inches, however, we have a pressure of 693 pounds to the square inch.

The diagrams, Figs. 3 and 4, were drawn to exact scale in order that the reader could form a comparison at a glance of the disbursement of the crank effort. For instance, take the lines on the horizontal plane as *2* and *3* and the vertical ones as *4* and *5*. By comparing these same spaces on the two pins in Figs. 1 and 2 it will serve to give a clear conception of the increased surface of the crank pin. When the two are in comparison, the force of the turning moment is clearly laid out by the "darts." The increased surface of the pin is clearly set out here, showing the disbursement of the pressure brought to bear by the force of the moving parts. The dotted line in Fig. 5 is the scale of the size of the smaller pin, and by comparing the arc of the circle in the spaces on the horizontal lines *4* and *5* and between the vertical lines *4*, *5* and *6*, it is seen that the large pin offers more surface for the direct pressure of the piston. Going back to the lines *2* and *3* on the horizontal plane and the vertical lines *2*, *3*, *4* and *5*, and comparing the surface presented by the semi-circles in Fig. 5, we have laid down the lines of pressure of the piston, the bold lines representing the large pin and the extended dotted lines representing the smaller. In this illustration, it is quite clear that the lines of the turning moment, extending to lines *1* and *2* would be lost on the smaller circle. Consequently, these lines must fall in with the others, classifying the direct pressure of the moving circle. It seems quite in evidence from theory and practice that the larger crank pin has its direct advantages. Of course, this could be carried to an extreme and the pin made so large that the velocity of the moving surface would be too great, but this point is stronger in theory than for practical use or comparison.

The pressure on the pin shown in Fig. 2 is one adopted by a builder for the same size of engine as the one having a pin of the dimensions shown in Fig. 1. On this pin we find that we have a total area of 55 square inches, as against 44 square inches in the first case. With the same piston area and a total pressure of 15,255 pounds, and figuring the area of one-half the pin, we have 27½ inches; so, to divide our sum total of pressure by this, we find that we have on each square inch of the crank shown in Fig. 2 an average pressure of 554 pounds, as against the 693 pounds in the first case, on the same size of engine with the same load and speed. This is certainly in favor of the construction shown in Fig. 2.

Another construction in making the cast-iron crank pin is that of putting in a very soft open iron, which is wrong; an engineer should demand a close-grained iron, preferably a semi-steel casting having a close grain. The cast-iron crank pin makes a good one when it is properly constructed from the right material. When a close-grained cast-iron crank pin becomes glazed, there is nothing that runs better.

In some of our good engines we find very faulty construction. Fig. 6 is a fair example which shows a section of a low-pressure valve on a cylinder having a 20-inch bore and a balanced flat valve of the Sweet type. It is generally understood that this valve does not require anything to carry it, but I fear that many who are well acquainted with this valve will agree that a valve-stem dynamometer would show that same effort, beyond what is generally understood to be necessary.

It is very strange that some of our good designers will make large eccentrics, large pins and plenty of wearing surface in the valve gear, so they will remain in adjustment, and then put in a valve stem like the one shown, having a boss 1⅜ inches in diameter, an area of 1.48 square inches and on the opposite side an area of 0.78 square inch to carry the valve that will weigh considerable, to say nothing of friction.

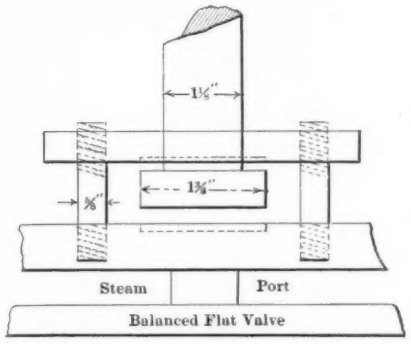


FIG. 6

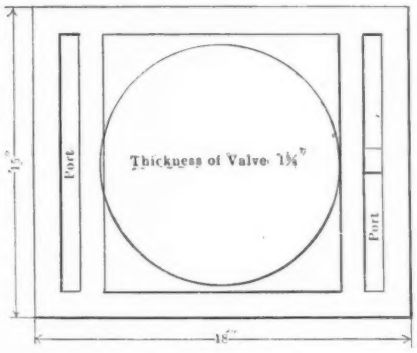


FIG. 7

The approximate dimensions of the valve are shown in Fig. 7. This will give the reader some conception as to the weight and inertia offered by a piece of cast iron reversing its moment at a speed close to 300 times per minute. This alone would require more wearing surface than presented, in order to wear well, if there were no friction at all to overcome. The result is that they soon wear in at the end as shown by the dotted lines in Fig. 6, both on the yoke and the end of the valve, and then the engineer has to tear down the whole valve gear in order to remove the small click that can be heard. If a liner is put in, it will soon wear again, as it cannot be clamped tightly, and at least it should not be for the sake of the valve. Such surfaces are just as important as the fine surface in the valve gear. It is troublesome to get at and requires some time to tear down the valve housing in order to get at the adjustment.

Future Problems of the Engineer*

By F. W. Ballard

When we review the past it should be for the purpose of classifying what we have done and studying its lessons for the future, and the more we study the past in this way the more we may know of the future. The different steps in the development of the past can be used as the engineer uses his points in plotting a curve; by the location of the points he learns its direction and the laws of its curvature, and thus he can plot it far beyond the limits of his data; and even so, to a certain extent, we may be able to foretell our future by a study of the successive steps in the evolution of the past.

Fuel Supply Limited

We have only recently awakened to the fact that we have been so wasteful of the natural resources of our country that, unless a radical change is soon brought about, our children's children will be face to face with poverty and humanity will again be fighting, like primeval savages, for food and shelter. But few people realize how absolutely dependent we are for the necessities of modern civilization, to say nothing of our luxuries and conveniences, upon our supply of fuel. According to statements of officials of the United States Geological Survey, the future life of our coalfields may be only about 200 years; while if the present rate of increase in consumption is maintained, they would last us only about 100 years more. The increase in the consumption of coal since the year 1815 has been such that the consumption during any 10 years has been double that of the previous decade, and equal to the total previous consumption. From the year 1895 to 1905, the consumption was over two billion eight hundred million tons. If we were to go on at this rate without any increase in the consumption of one year over that of the past year, it is estimated that our supply would last about four thousand years, and this figure is not so startling. It is hardly likely, however, that we would stop all increase in the coal consumption now when we have had an almost uniformly geometrical rate of increase for the past nine decades. The actual figures, as given by the Geological Survey from the census returns are as follows:

	Tons.
1815 to 1825	331,356
1825 to 1835	4,168,149
1835 to 1845	23,177,637
1845 to 1855	83,417,825
1855 to 1865	173,795,014
1865 to 1875	419,425,104
1875 to 1885	847,760,319
1885 to 1895	1,586,098,641
1895 to 1905	2,832,599,452

Of course, as everyone knows, it has been the wondrous increase in the industries during the last century which has called for the large coal consumption chiefly for power. In 1870, the total steam power used was 2,500,000 horsepower. In 1880 it was about four million. In 1890 it was eight million. In 1900 it was sixteen million, and at the present rate of increase it will be thirty million horsepower in 1910.

The Gas Engine a Possible Solution

All the steps which have been made so far looking toward economy in the use of steam power and in its generation are really insignificant. The ordinary steam engine does not convert more than 5 per cent. of the total energy of the coal into useful work, and in most highly developed modern plants the efficiency never rises above 10 or 12 per cent. We have about given up hope of ever doing much better than this with the steam engine; and it is more than possible that the gas engine, used in connection with producer gas, may revolutionize our methods of converting the energy of coal into useful power and to a large extent replace the steam engine. The efficiencies of the gas engine are more than double the best that have ever been obtained with the steam engine, and the complete demonstration of continuous and reliable operation of the gas-producer plant on bituminous coal will be followed by the general adoption of this source of motive power.

Hydroelectric Development

The generation and distribution of electrical energy from hydroelectric power plants is receiving as great an impetus at the present time as any other means for the generation of power. In 1890, the total water-power development was about 1,500,000 horsepower; in 1900, it was 2,200,000, and in 1910 it will be over three million horsepower. Although the cost of installation of hydroelectric plants is considerably greater than that of steam plants, the cost of operation and maintenance is very much less, and the additional fact that no fuel whatever is consumed makes the cost of power generated so much lower than the cost of steam power that energy can be transmitted from these developments for many miles and still be sold for half the cost of steam power, with a handsome profit to the investor. In fact, the available power sites are being taken up so rapidly that the next 10 years or so will probably see all of the more profitable possibilities fully developed. This, of course, tends toward a decrease in the total steam power neces-

*Abstract of presidential address to Ohio Society of Mechanical, Electrical and Steam Engineers.

sary to supply the needs of industry, but the total possible economical development of water power in the United States is only about thirty million horsepower, and there is that much steam power in use at the present time, and at the present rate of increase there would be sixty million in use in another 10 years. Thus it is quite evident that the development of the total water power possible would not materially lessen the coal consumption. In fact, if the present rate of increase continues, in but a very few years the price of coal will soar to undreamed-of hights, chiefly because of the difficulty of transporting it in sufficient quantities. The difficulties of transportation are by no means imaginary. They are already upon us, and will become most serious indeed with but a small increase of industrial activities. The result will be a scarcity of coal for power purposes and an increase in the cost of steam power.

Alcohol as Future Fuel

That there is a possibility of a future fuel supply in the growth of vegetation from the soil is quite evident when an assemblage of all the facts bearing upon the subject is considered. The manufacture of alcohol from vegetation and its use in the internal-combustion engine opens up the way to possibilities as yet undreamed of. The fact that in the manufacture of alcohol all the substances used are those which the plant obtained from the atmosphere and that also all those nitrogeneous compounds which were drawn from the soil may be immediately returned as fertilizer naturally suggests that alcohol is the proper logical vehicle for the transmission of the sun's energy from the plant to the engine. The great progress that has been made in recent years by such men as Luther Burbank in the development of different species of plants to suit any requirements, and the possibility of manufucturing fertilizer by electric power from the nitrogen of the atmosphere open up possibilities for the growth of vegetation of the proper kind and in sufficient quantities to meet great demands for power and heat.

It is maintained that alcohol can be produced and marketed much cheaper than the prevailing price of 40 cents per gallon, and that it should soon become a very strong competitor of gasolene for power purposes, both in price and quality. From tests made by the U. S. Geological Survey it was shown that under the most favorable conditions that could be obtained, equal amounts of 73-degree gasolene and commercial denatured alcohol by volume were used per unit of power. Considering the fact that the heat value of a gallon of the alcohol is only about six-tenths that of a gallon of gasolene, the tests showed a much higher efficiency for the alcohol. The amount used was eight-tenths of a pint per brake horsepower per hour for both gasolene and alcohol. It is generally conceded that alcohol can be made equally efficient, if not more so, as gasolene, and that the difficulties in the way of its practical use are pretty generally understood and are by no means insurmountable.

Regarding the possibility of raising sufficient quantities of grain or vegetables to meet power requirements, the following data may be of interest:

	Pounds.	Gallons Absolute Alcohol.
1 bushel corn yields	16.53	2.5
1 bushel rye yields	15.73	2.4
1 bushel white potatoes yields	5.25	0.8
1 bushel sweet potatoes yields	6.95	1.1
1 gallon molasses yields	3.00	0.45

Corn and white potatoes seem to be the favorite materials used in this industry. In the United States in 1895 the total acreage of land in corn was ninety-four million with an average yield of 28.8 bushels per acre, and the total production was 2700 million bushels. If this had all been used for the manufacture of alcohol, we could have made from this source alone a total of 6750 million gallons, and this would have been sufficient to generate over 20 million horsepower for 10 hours per day for the whole year, or two-thirds of the total power now used in this country. There are in round numbers approximately 2000 million acres of land in the United States, and it would no doubt be quite safe to estimate the total area available for agricultural purposes at 1000 million acres at least, or more than ten times the amount in corn in the year 1895.

Potatoes seem to be the material most generally used for the manufacture of alcohol in Germany, the country which at present leads in this industry, and while the average yield in the United States is only 45 or 50 bushels per acre, they have grown as high as 600 bushels per acre in that country, where a special kind of potato is used—one that has been developed particularly for the purpose of manufacturing alcohol. During the year 1903, England made two million gallons of alcohol for industrial purposes, France eight million and Germany 25 million. It requires about three bushels of potatoes to yield as much alcohol as one bushel of corn, but if it is possible to obtain a yield as high as 600 bushels of potatoes per acre it would require only one-tenth of our tillable soil to produce a yield large enough to supply alcohol for seven times the power now used in the United States.

Of course, there is not much encouragement for the production of alcohol for power purposes as long as the price remains four times that of gasolene. However, attention has recently been called to the possibility of making alcohol from peat and selling it at a price as low as five cents per gallon. It is said that the peat beds in the Great Dismal Swamp of Virginia are capable of yielding 40,000 million gallons of alcohol. This amount would be capable of supplying the United States with power for only about four years; but as long as the mineral-fuel supply lasts, alcohol would be used only for certain special purposes, and in small quantities at first, although at five cents per gallon it would be on practically an equal basis with coal at $2 per ton, considering the present efficiency of the average steam-power plant. The peat beds should serve for the manufacture of alcohol for many years, and meanwhile we should learn to produce much cheaper alcohol from vegetation and take steps looking toward the production of some species of plant having a much more luxuriant growth and better adapted for the purpose than those we now have.

When the manufacture of alcohol from the season's vegetation becomes a large industry in our country, with stills located at convenient points for the delivery of vegetables or grain and the return of the refuse to the soil as fertilizer, we will be completing a cycle which can be maintained season after season and year after year and so on for ages without disturbing or changing in any way the condition of the soil or quality of the air we breathe. All those substances which the plant takes up from the soil are left behind when the alcohol is made, only those substances going into its composition which the plant derived from the atmosphere, these even being returned again to the air in identically the same form when the alcohol is consumed.

Depleting Oxygen Supply

On the other hand, every ton of coal which is burned uses up 300,000 cubic feet of air and renders it unfit for breathing. Suppose that there were no danger of exhausting our coal supply, and that we had enough to last forever; it would only be a few hundred years at our present rate of increase in coal consumption, and incidentally oxygen consumption, until all the atmosphere on the earth's surface would be rendered incapable of sustaining life. However, as has been called to our attention by Professor Arrbonius, the consumption of coal at present is returning to the atmosphere the carbon dioxide of which it was robbed when the deposits of carbon were stored away in the coal beds during the carboniferous period. The present proportion of carbon dioxide in the air is about one part in 2500. This would be more than doubled by the consumption of the present known coal deposits, and it is stated that a doubling of the quantity of this gas in the atmosphere would more than double the rate of growth of plant life.

Maintaining Fertility of the Soil

As to the question of the necessity for maintaining and increasing the fertility of the soil, it would seem a fortunate thing that we are now learning a method of manufacturing fertilizer by means of electric power, just when we are beginning,

as it were, the development of the great water power possibilities of our country. Here is an industry that can be located at the sites of hydroelectric plants and should be a stimulant to their development on a much larger and more complete scale than heretofore. The difference between the summer flow and the winter flow of most rivers is quite large. In some the average flow for six months in the winter is more than three times that of the summer months. In most hydroelectric developments, the size of the plant is determined by the minimum flow, or at least by the average summer flow, the periods of minimum flow being taken care of by auxiliary steam plants. The reason, of course, is that the commercial demand for power is mostly for continuous power without interruption the year round. The power going to waste during the winter months at otherwise fully developed plants could be utilized to good advantage on such an industry as the fixation of atmospheric nitrogen, which requires no materials except the air and cheap power.

Nitric Acid and Nitrates from the Air

The process of manufacturing nitric acid and the nitrates from the nitrogen of the air is past the experimental stage. As the amount of power required per unit output is very great, the problem is resolved into the question of cheap power and the best efficiency possible in the apparatus employed. The great importance of the problem has caused many of our best scientists to devote much time to its solution. One line of operation makes use of electric discharges through air to combine the oxygen and nitrogen in the air, thus producing nitrates. The Atmospheric Products Company, at Niagara Falls, has undertaken the largest plant for this purpose, but has not been able to establish a permanent industry. There has, however, been a smaller plant established in Norway, which has been running for several years with considerable success. The power cost for this installation is remarkably low, because of unusually favorable conditions incident to the hydroelectric development. The power cost is figured at $5 per horsepower per year, and the output of the plant is about four pounds of 70 per cent. nitric acid per horsepower per 24 hours.

There are recent reports of a new process for the fixation of atmospheric nitrogen, which is said to produce a much greater output per unit of power than has heretofore been realized. A small experimental plant of 350 horsepower capacity has been installed at Joliet, Ill., and will use power from the development there in the Chicago drainage canal. It is claimed that they have been able to produce 12 pounds of 70 per cent. nitric acid per horsepower per 24 hours. This at $20 per horsepower-year would be on the same basis as the Norway plant, and would make the power cost about ½ cent per pound of acid. Of course there are other costs to be figured for the process outside of power, such as interest on the investment, operating costs, maintenance, etc., but the power cost is greater than all the others combined, and in the production of calcium nitrate the total cost would come within $20 per ton. Calcium nitrate is said to carry a larger percentage of nitrogen and to make a better fertilizer than the sodium nitrate which is being manufactured from the Chilean saltpeter, and which has a market value in New York of $48 per ton. It is claimed by parties interested in the Joliet plant that a larger output than 12 pounds per horsepower per day can be secured with a larger and better equipped plant, and that the theoretical possible output is 45 pounds, if all the energy were utilized in the fixation of the nitrogen. This, of course, could never be realized in practice, but it indicates possibilities for better results from higher efficiencies than have heretofore been obtained. The information in regard to the Joliet plant was obtained from E. N. Sprague, of Cleveland.

Another method for the fixation of atmospheric nitrogen for the production of fertilizers, is that known as the Frank-Caro process. Calcium carbide is first ground to a powder in air-tight mills, filled into a furnace which is kept full of nitrogen, and raised to and maintained at a temperature of 800 to 1000 degrees Centigrade for several hours. The product is known as calcium cyanide, and is coming to be used quite extensively as a fertilizer all over the world. The process is cheap enough to permit of competition with other fertilizers, and it is stated that the capacity of works now in process of construction in different parts of the world aggregates over 45,000 tons.

In this process, it is necessary first to manufacture the calcium carbide in the electric furnace, which calls for a supply of coal as well as lime in the raw material. It is also necessary to supply an atmosphere of pure nitrogen in the furnace. This can be obtained in large quantities in a practical manner only by means of the differential distillation of liquid air, the nitrogen and oxygen being given off in such a way that they can be collected separately. Although the products of this process are evidently satisfactory for fertilizing purposes, yet it is to be hoped that we will see within the near future the process of the fixation of nitrogen directly in the electric furnace placed on a commercial basis.

A Radium Motor

The wonderful discoveries which have been made by our leading scientists during the last five or six years concerning radium and radio-activity have played vividly upon the imagination of those who have been following the rapid succession of events and discoveries. Some of our recognized leaders as engineers and scientists have enthusiastically predicted the early invention of a radium motor, and the popular magazines and journals of the day are eagerly picturing for us "man's machine-made millennium," "when power will be so cheap that none will work except for recreation." Such predictions and vividly imaginative pictures of the future are extremely harmful. They tend to quiet the mind of the people and offer the assurance that somehow, by some means, mankind is to be taken care of in the future; that we need take no thought of the morrow. Storehouses of nature will be opened up to us, inviting us to prodigality and luxury undreamed of at present.

Economy the Keynote

We should by no means attempt to minimize the possibilities which would result from new discoveries, but on the other hand it is very harmful to exaggerate them. The most successful engineers are those who are ever conservative in their estimates and statements. The problems of the engineer of the future will be largely those of economy. Whatever will result in the cheapening of the cost of production and distribution of the necessities of mankind will be his work. The production of labor-saving machinery, finding and developing the most economical source of power, and the great question of transportation are no doubt the most important of present-day problems. The problems of the future will not be radically different, but will be of vastly greater importance and greater scope, and economy will of necessity be the keynote to their solution.

If our country and the earth are to increase in population in the future as we all believe they will, the demands upon the engineer will increase, and as we are already demanding more intelligence and technical ability of the trained and industrial worker, so will the future demand more intelligence and ability in the engineer. We are only just beginning to feel the dependence of society upon the engineer. Society in the future will know that it owes its very existence to him. As the great industries of the present compare with the small businesses of our grandfathers' time, so will the future organization of society compare with the present organization. Engineering will be the most prominent of all the professions. Specialization will be carried to a much greater extreme than now, but on the other hand we will also have the industrial engineer whose general knowledge and experience will be much wider than that of any we now have, and it will be upon the genius and breadth of mind of these men that the world will depend for its sustenance, its conveniences, its luxuries, and, in fact, all those conditions which will make possible the existence of a race of human beings whose numbers shall be many fold the population of the earth today.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

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Power Plant Charges

The editors of POWER are often asked to decide a dispute, or settle a controversy, or arbitrate a bet by passing upon some engineering question. We dislike to do this because there is room for argument as the case is generally stated, and it is entirely possible that both sides may be right.

Here is a case in point: "To settle a discussion please advise me as to the proper method to follow when determining the cost per kilowatt-hour when the current is derived from a direct-connected steam-driven unit. That is, knowing the cost of the boiler horsepower per hour for the whole steam plant, which is used for various purposes, what means is used to determine the amount chargeable to the unit referred to, assuming that the total of horsepower-hours of this unit is known?"

It is easy to see how an interminable discussion could be kept up over this question stated in this way. If the average consumption of the engine per kilowatt-hour, as well as the total number of kilowatt-hours, is known, their product will be the number of pounds of steam used in that time. If the cost of making the steam is known, and it can be deduced from the given "cost of the given boiler horsepower per hour," the cost of steam for running the engine can be found by simple multiplication. The most uncertain factor in the stated calculation is the average steam consumption of the engine. It will take more steam per horsepower-hour when running under- or overloaded than when upon its rated load. Only by knowing its efficiency at different loads and keeping track of the periods that it runs upon each can the cost of the steam which it uses be even approximately determined.

But is this what is wanted? The proprietor may want to know how much more he will spend in a year if he puts in this engine than if he does not. In this case you must charge the engine with the interest upon its cost, and a fair rate of depreciation, for an engine will not last forever and you are using up so much engine every year; you must charge whatever extra taxes and insurance its ownership will incur. You need not charge extra rent or attendance if the floor space is available and there are already enough attendants to take care of it. You must charge it with oil, waste, etc., and probable repairs. The cost of the steam to be charged to it for this case will be considerably less than a proportionate part of the whole cost of operating the boiler room, for once you have the boiler plant in operation it costs comparatively little to make a little more steam.

In other words it depends upon what purpose or question the account is supposed to serve or answer. If it is a matter of distributing the total charges between different accounts one method is to be followed, if it is to determine between the desirability of purchasing current or putting in one's own generating set another process is necessary and a degree of accuracy may be essential in one case that it would be foolish to strive for if the question were simply one of which page the entry went onto, or in which pocket the money was kept.

Municipal Electric Light Plants

From Wisconsin comes a newspaper clipping which says: "Municipal ownership has been recently tried and abandoned by a number of Wisconsin cities, Racine, Sheboygan, Appleton and Whitewater being among them, and Chicago reports having lost over $200,000 the past year in a costly experiment in the matter of municipal lighting, and is now satisfied that a city cannot run a lighting plant as cheaply as private companies can supply the lighting."

Grafting, which "inevitably takes place with municipal ownership," is the only reason assigned by the author of the clipping for the failure of municipal-lighting plants to pay. If the inevitability of grafting be admitted, which it is not, it is doubtful if the statement that a city can buy current cheaper than it can make it is true. In the open market it can borrow money with which to build at a lower rate of interest than any private corporation. It can employ equally expert men in all lines of station construction and operation work at as good or better prices than any private concern.

Cost of production and distribution in plants serving all sorts of communities, from the most densely populated cities to the rural districts, is a figure either well known or easily obtainable, and the same set of men can do equally good work whether employed by the city or by a private company and the operating expenses of a municipal plant would be no greater than those of the privately owned plant. Depreciation, repairs and taxes would be the same in both cases, but the lower interest rate on the money invested would be in favor of the municipal plant.

Graft, ignorance and incompetence obtain in municipal matters in many cities but not in all, hence are not inevitable. In any municipal plant the necessary expense of producing current can be increased one hundred per cent. and then cost less than any private corporation will sell it for. No excuse is made for graft, there is no excuse for it; it is plain, simple stealing and should be treated as such.

Let the business men of any municipality take up the question of municipal lighting, just as they would take up any other business proposition, discuss it and decide it on its business merits and not as a scheme by which some politician can be enabled to pay political debts, and

municipal lighting will be found to be the cheapest possible method of lighting.

This means, of course, a careful examination of all conditions by a man of experience in such matters, and the following of his recommendations to the letter, the selection of a manager who has no interest to serve except that of the community; and this man, too, must be a man of wide and successful experience, one capable of carrying out the suggestions of the chief advisor. Put a properly designed municipal plant into the hands of such a man, asking for results, and results that no privately-owned plant with all of its modern business methods can beat will be easily and continuously obtained.

Extraneous Supervision of Power Plants

Companies have been organized and individuals have undertaken in several of the large cities to run one's power plant for him cheaper and more satisfactorily than he can run it himself. The system is founded on the following proposition, set forth in a pamphlet entitled, "Engineering Supervision of Power Plant Operation," by Percival Robert Moses, and issued by the Engineering Supervision Company, of New York, of which Mr. Moses is understood to be the moving spirit:

> Up to within the past two or three years it was the custom to put the operation of the steam and electric plant in charge of the chief engineer, who was usually a man who had gained his experience by hard work in the fire room and afterward as an oiler oiling the engines, and finally obtaining a license to operate as chief engineer, or as assistant engineer, as the case might be. These men were rarely educated along technical lines, although they had a good practical knowledge of the operation of the particular machinery to which they had been accustomed. It was found, however, that these men were not altogether fitted to assume responsibility, that they were frequently led astray by ambitious agents and graft was becoming a usual accompaniment to engine-room operations. In the purchase of oils, fuel and the making of repairs it became the custom in more than one-half of the plants for the engineer to receive anywhere from 10 per cent. to 50 per cent. of the cost of the work. This led to the withdrawal of the purchasing from the engine room, but the engineer condemned the materials used unless he received his graft.
>
> Many owners, recognizing that their knowledge of the operation of mechanical equipment and of electrical apparatus was very limited, retained a consulting engineer to advise them on changes proposed, and finally several companies were started with the sole object of taking charge of the operations of plant and mechanical equipment on behalf of the owners. Two distinct methods have been adopted in this work; the first method is the method adopted by the contracting engineering companies in making a contract for a fixed sum, for which payment they agree to operate the mechanical equipment and maintain it in good repair; the second method, that of engineering supervision of power plants, has been developed more recently and has met with a great deal of success.

This method, the pamphlet urges, places an engineering office at the disposal of the owner, the help is hired after investigation of references and personal examination of the applicants, and the multiplicity of opportunities controlled by the contractor operating a large number of plants enable him to advance the worthy and to assign the men to the positions for which they are particularly adapted as well as quickly to replace a force which has gone out on strike.

"An engineer realizing this fact," ingenuously remarked the author, "knows that he cannot be arbitrary."

Fuel and supplies can be purchased in large quantities to the best advantage, and if the contractor gets the benefit of commissions and discounts, his client profits by it in the lower price at which he can afford to take the job. A corps of trained inspectors keeps up the standard of efficiency, in connection with a system of log keeping, which enables the contractor to tell what is being done at each of the places under his charge, and the department of supervision and repairs brings to bear expert engineering knowledge and skill, as well as business relation and the economies of large dealings, upon alterations, replacements, extensions and repairs which are beyond the capabilities of the working force.

This is the contractor's presentment of the case, and it is a good presentment and a good case—if the premises are correct. It concentrates the engineering skill in a working bureau and reduces the man in local charge to an attendant with no further need of interest, knowledge or skill than is necessary to do what he is told and to write it down in a logbook. In a place where the conditions cited in the paragraph which we have reproduced obtain, in a place where the man in charge is a greaser and "not altogether fit to assume responsibility," in a place where the employer is paying a commission to the engineer in addition to his wages, and a legitimate profit upon the supplies which he buys, such a system offers material advantages. The perpetuation and growth of such a system is altogether in the hands of the operating engineers. If they permit the establishment and the continuance of the conditions cited by that paragraph, the contracting engineer will find his opportunity and make good his proposal. If, on the other hand, the man in charge is a real engineer, up to the possibilities of his position in real engineering knowledge and ability, and is honest with his employer, not only in the handling of the purchases which are committed to his charge, but in interested attention to his work, in realizing possible economies, in foreseeing and heading off possible interruptions to the service, and if he qualifies as an intelligent adviser in all the matters relating to his department, the employer will have little use for engineering advice and supervision outside of his own establishment, and the contracting engineer little chance to replace him with the mechanical automaton of which he will work the strings.

Gas Engine Overload Ability

For ordinary classes of service there is no logical excuse for demanding overload ability in a prime mover. Where the load fluctuates widely and rapidly, as in electric-railway and rolling-mill service, there is often justification for requiring overload ability, although in many cases the requirement can be obviated and smoother operation obtained by the use of power storage.

However, granting that the need for overload ability does exist in a limited number of cases, does it necessarily follow that the gas engine is unsuitable for use as a prime mover in such cases? We have frequently been told that the gas engine has its maximum efficiency at maximum load—one well known physicist seems unable to talk on any gas-engine topic without lugging this statement in by the heels. The statement may be true, but it would need more than the unsupported utterance of it to convince us of its accuracy, at least as regards producer-gas engines. It is well known that there is a point beyond which increasing the compression does not increase the brake economy of the engine; if any given engine were rated at that point but designed to cut off the charge prior to the completion of the intake stroke, its compression when the governor admitted during the entire stroke would be beyond the critical point, and the engine would have additional capacity beyond that at maximum efficiency. This is not a discovery; it is perfectly well known to experienced designers, and there are many conditions under which such a method of design seems practicable. It is not so, of course, when gases rich in free hydrogen are used for fuel, except, possibly, by diluting the mixture excessively and using multiple ignition. In all usual cases, however, where overload ability is justifiable, either natural gas or a lean gas is used, and high compression is practicable.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Detroit Automatic Stoker

The Detroit automatic stoker, manufactured by the Detroit Stoker and Foundry Company, Detroit, Mich., is shown herewith, with two methods of feed, the worm-conveyer or screw feed, and the reciprocating or pusher feed. The worm-conveyer feed, Fig. 1, is suitable for installations of smaller proportions or units of one or two stokers in a battery of boilers, especially in cases where the coal is to be shoveled from the floor by hand. This method is also convenient when the flush-front setting is desirable, occupying no more space in the boiler room than ordinary hand-fired furnaces.

The reciprocating or pusher feed, Fig. 2, is recommended for larger-sized units, when it is desirable to feed the coal by machinery from overhead bunkers on top of a dutch oven or extension-front setting; also, when the requirements for steam are irregular and the load is extremely variable. Figs. 3 and 4 show the appearance of the boiler fronts when equipped with both types of feed.

Attention is called to the operation of the grates at both ends, and the method of handling the clinkers by means of clinker crushers located in the center of the furnace and shown in detail in Fig. 5.

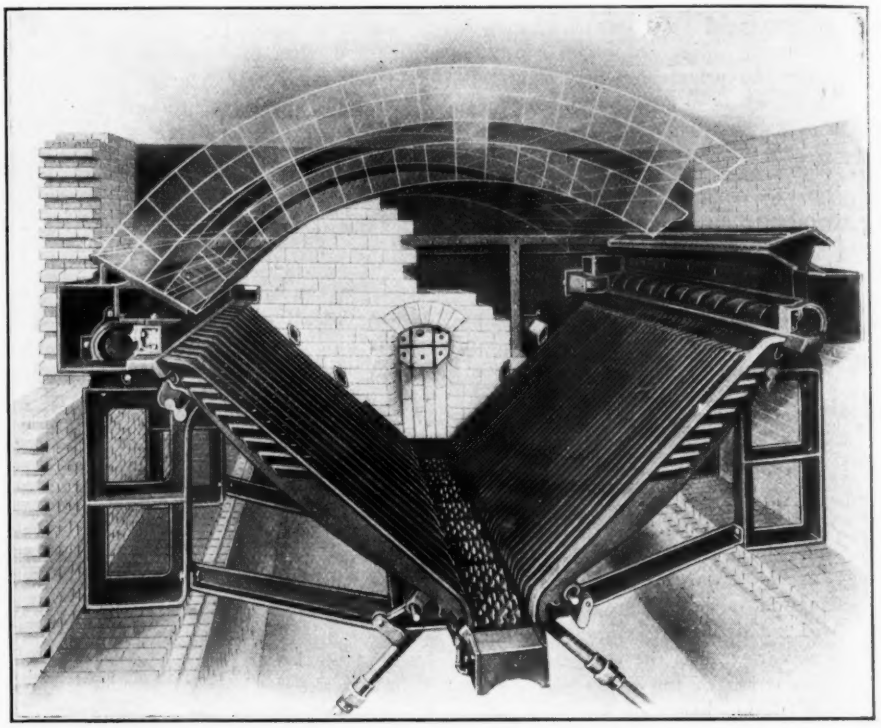


FIG. 1. STOKER EQUIPMENT WITH SCREW FEED

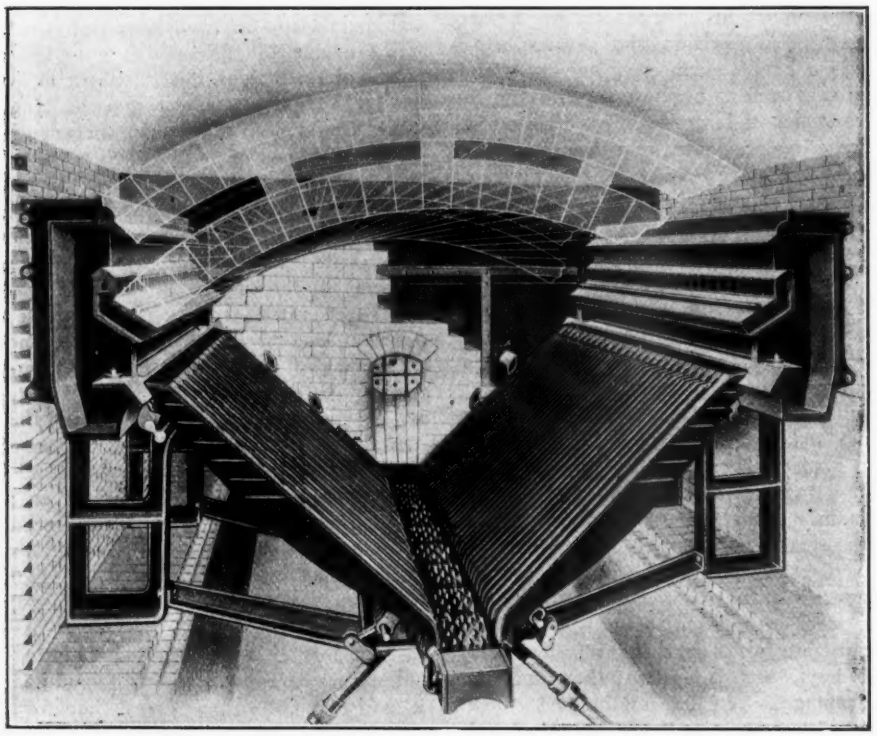


FIG. 2. STOKER EQUIPMENT WITH PUSHER FEED

One of the several advantages of this stoker is the double air-cooled arch, which produces very high efficiency and high furnace temperature. The admission of air through the stoker fronts between the two arches and the circulation assist in the maintenance of the brickwork and allow the right amount of heated air, under control, which is admitted to the furnace over the coking plate, at which point the hydrocarbon gases are released and mixed.

By moving the grates at both ends the coking coal is broken up, and air allowed to penetrate the fuel, to prevent the formation of clinkers on the grates until the center of the furnace is reached.

The clinker crushers in the center, Figs. 1 and 2, are a row of cast-iron disks, built in different sizes according to the size of the stoker, which rotate toward each other, grinding the clinkers and depositing them in the ashpit below, thus eliminating the labor of cleaning the fires by hand, and subjecting the boilers to a rush

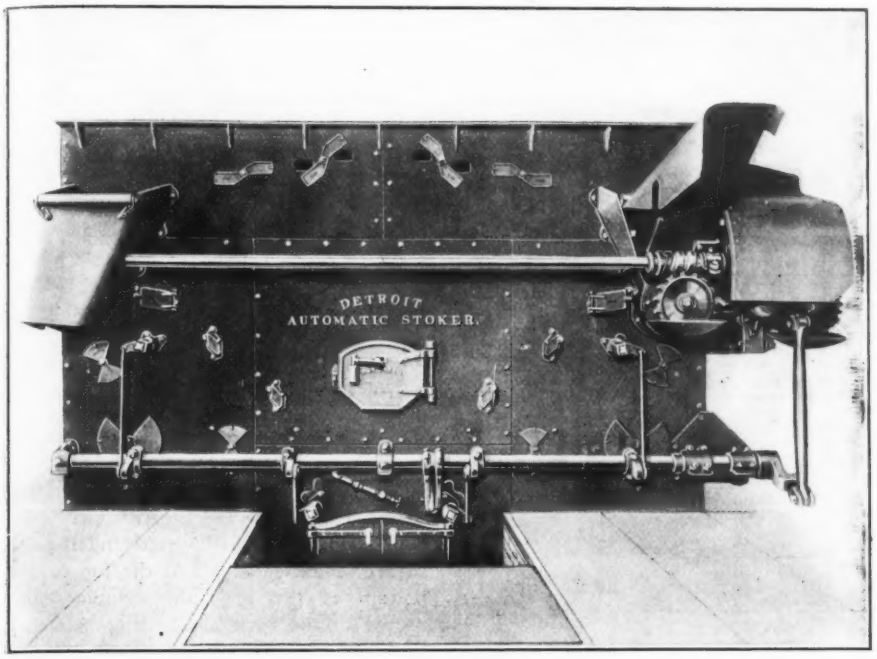


FIG. 3. FRONT VIEW OF STOKER EQUIPPED WITH SCREW FEED

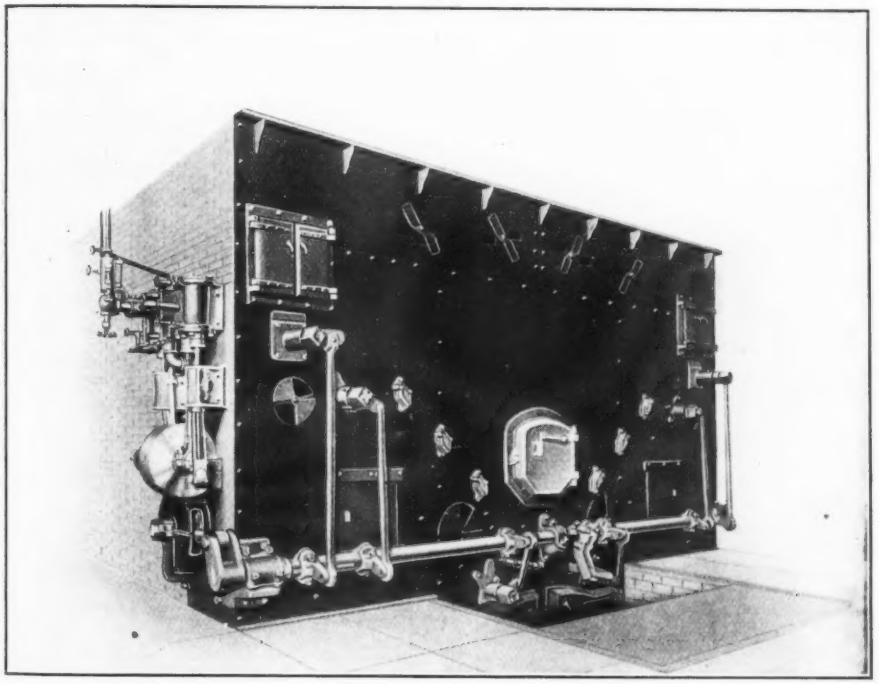


FIG. 4. FRONT VIEW OF STOKER EQUIPPED WITH PUSHER OR RECIPROCATING FEED

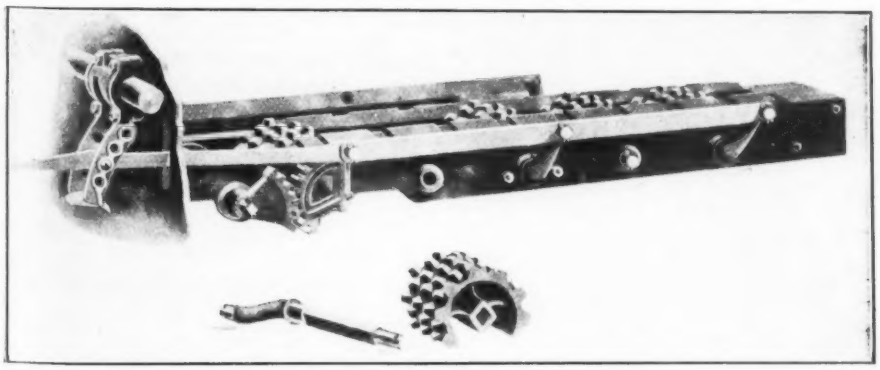


FIG. 5. CLINKER CRUSHER IN DETAIL

of cold air through the fire door, and also reducing the temperature of the furnace and efficiency of the boiler.

These stokers are operated by small automatic steam engines or electrically driven motors, which are placed on either side of a battery or boiler. As shown in Figs. 3 and 4, the operation of the grates is controlled by connecting links in front, and the clinker crusher from the lower shaft, which makes a most flexible arrangement.

Automatic Fuel Oil Regulating System

The principle of operation of the Moore automatic fuel-oil regulating system is as follows: The system controls the supply of oil to all burners, the supply of the atomizing agents to all burners and the supply of air for combustion to any number of boilers, all from a central point. In this system all the individual burner valves, both steam and oil, are opened wide, or nearly so, and all burners are operated under full pressure in the respective mains. In the larger plants all dampers are connected to a common rock shaft and move simultaneously.

A slight variation in the steam pressure of the boilers is the primary means of controlling the governor which varies the oil pressure at the oil pumps and in the oil main. Corresponding to an increased pressure in the oil mains, there is an increase in the amount of fuel fired and a raise in boiler steam pressure; and corresponding to a decrease in the pressure of the oil mains, there is a decrease in the rate of oil fired and a lowering of the boiler pressure. Thus, a uniform steam pressure is maintained within the limit of the governor. The variation in pressure in the oil main is a secondary means of controlling the supply of steam for atomizing purposes and also for controlling the supply of air for combustion.

The supply of steam to the burners is controlled by regulating the pressure in a separate low-pressure main common to all burners, the pressure in this main being a certain predetermined relation to the pressure in the oil mains and being controlled by a ratio regulator. By means of a specially constructed diaphragm regulator, the opening of the boiler damper is made to increase or decrease with a corresponding variation of pressure in the oil main, the change in the damper opening, in turn, governing the supply of air for combustion.

A reliable pump governor can be used to control the oil pressure in the oil mains in order to maintain a uniform steam pressure. The governor can be used to throttle the steam supply to the steam-operated oil pump, or a bleeder valve in the oil-discharge pipe. Satisfactory results can be obtained by the use

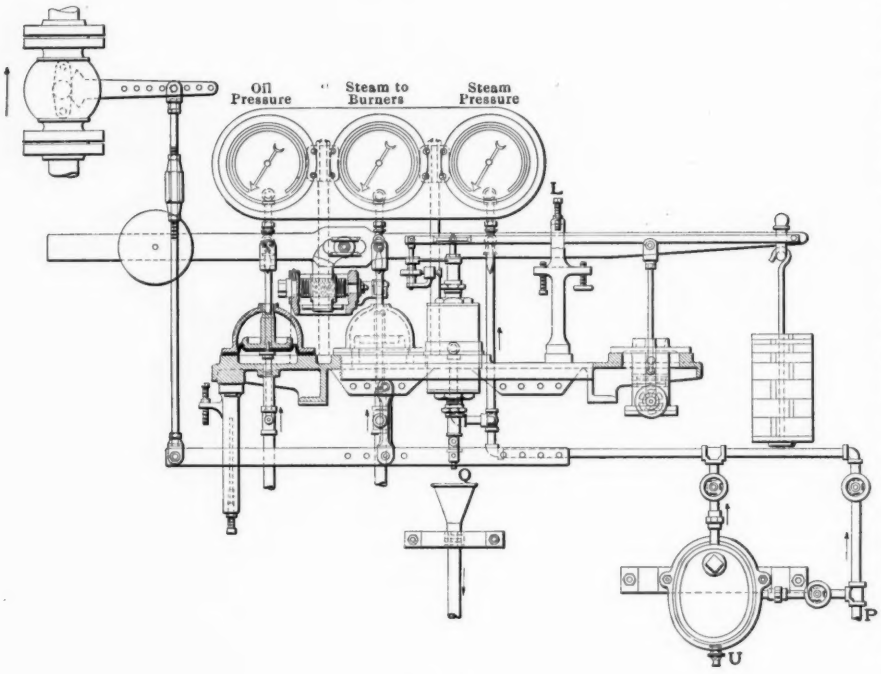


FIG. 1

of a damper regulator of proper type, the movement of the power lever being used to control the bleeder valve in the oil-pipe discharge in lieu of connecting it to the damper.

In the regulator shown in Fig. 1 the upward pressure is exerted on two diaphragms, the one to the left being subject to the oil pressure in the old main, the one to the right to the steam pressure in the low-pressure steam main connected to the burners.

The fulcrum is adjustable for a desired ratio of leverage. The yard arm is counterbalanced to the left and the weight at the right for the desired weight is constant due to the pressure-difference factor. Whenever equilibrium is disturbed by variation in oil pressure, the main yard arm will be compelled to move either up or down. This motion is communicated to a water cylinder or motor such as used on the Spencer damper regulator. The movement of the water cylinder in turn operates a suitable lever and connecting rod, and finally a rotary chronometer valve, which increases or decreases the supply of steam to the low-pressure steam main in such a manner as to restore equilibrium, thereby providing the desired increase or decrease corresponding to the initial change in the oil pressure.

In Fig. 2 is shown the final development of this regulator for large power plants. The large diaphragm is subject to the upward pressure corresponding to that in the oil main. The motion of the lever is opposed by a coil spring adjustable in position along the lever so as to obtain the required range of motion of the damper corresponding to the given range of boiler pressure. By means of a double--ported controlling valve, connected to the damper controller, the supply of water under pressure is admitted either to the top or the bottom of the hydraulic cylinder connected to the rock shaft. Fig. 3 shows the arrangement of boiler plants and the main piping connections for the steam to burner regulator and damper control.

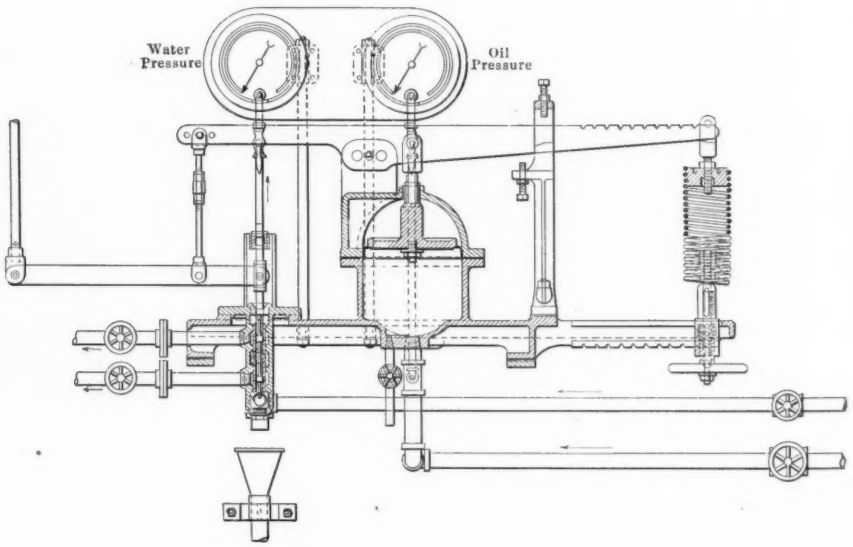


FIG. 2

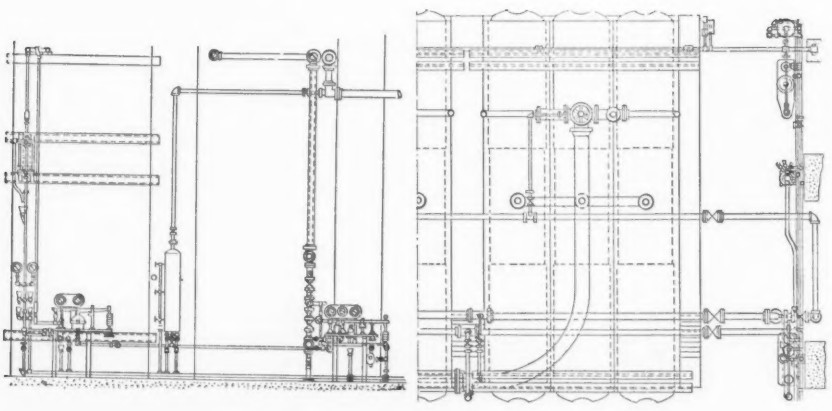


FIG. 3

This system of fuel-oil regulation was designed by C. R. Weymouth, of San Francisco, and is now owned and manufactured by Charles C. Moore & Co., also of San Francisco, Cal.

A Correction

W. E. Sargent's letter in the December 8 number, page 962, contained an error in a very simple arithmetical computation, in that he was made to figure the cost of power per day of 10 hours for a 150-horsepower engine, using 30 pounds of steam per horsepower-hour at $15 per thousand, as $675,000, instead of $675.

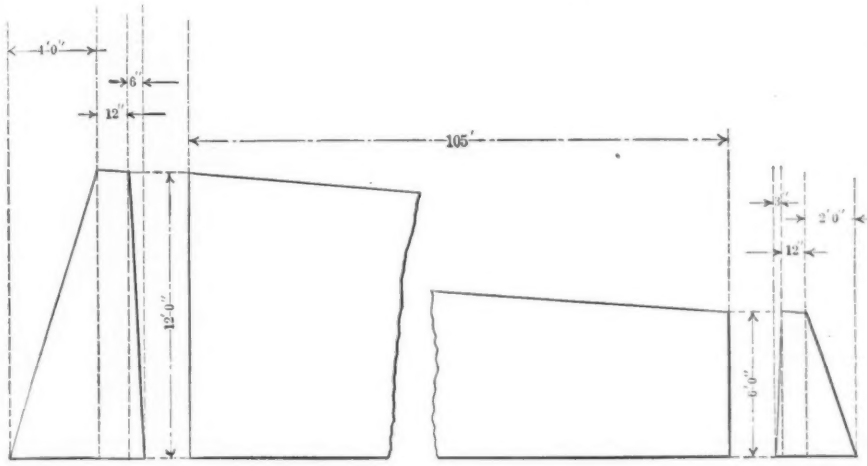
Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Computing Cubic Feet of Concrete in Wall

Will you please compute the cubic feet of concrete in a wall as shown by the accompanying sketch?

G. K.



COMPUTING CUBIC FEET OF CONCRETE IN WALL

Dividing the wall into three strips, we have two triangular prismoids and a truncated wedge. The rule for finding the cubical contents of prismoids is as follows: To the sum of the areas of the two ends add four times the area of the middle section and multiply this sum by one-sixth of the length.

First prismoid—Area of large end = 24 feet; area of small end = 6 feet; area of middle section = $13.5 \times 4 = 54$ feet; total, 84 feet.

$$\frac{84 \times 105}{6} = 1470$$

cubic feet. Middle wedge:

$$\frac{12 + 6}{2} \times 105 = 945$$

cubic feet.

Second prismoid—Area of large end = 3 square feet; area of small end = 0.75 square foot; area of middle section = $1.6875 \times 4 = 6.75$ square feet; total, 10.5 square feet.

$$\frac{10.5 \times 105}{6} = 183.75.$$

$$183.75 + 945 + 1470 = 2598.75.$$

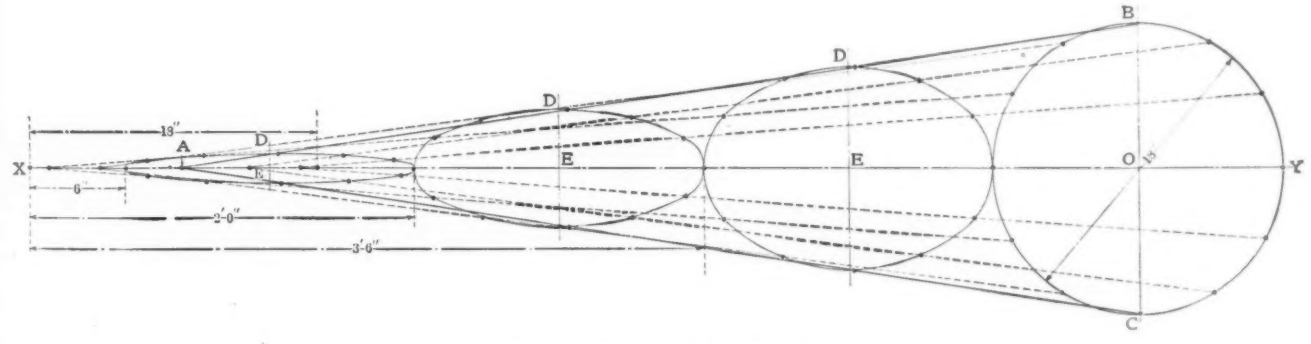
Path of Point on Connecting Rod

Through the columns of POWER AND THE ENGINEER will you kindly show how the path of a certain fixed point on the connecting rod of an engine can be determined. Take, for instance, an engine with a stroke of 18 inches and a connecting rod 5 feet long, and suppose the point to be 3 feet 5 inches from the center of the crosshead pin. Kindly give formula to obtain the distance this point will travel during one revolution of the crank.

F. B. R.

A point at the center of the crosshead pin will travel in a straight line, and the center of the crank pin will travel in a circle. The path of any point on the connecting rod between these limits will be an ellipse, the minor axis of which will decrease in length as the point approaches the crosshead. This is readily apparent in the accompanying sketch. To obtain the path of any point on the connecting rod for the period of one revolution of the crank, lay off the connecting rod and crank circle to scale, as shown in the diagram; then divide the crank circle into 30-degree divisions, and with a pair of dividers set to a distance equaling the length of the connecting rod, strike an arc intersecting the horizontal line XY, which represents the connecting rod in dead center position. Join the points on the horizontal line and the crank circle and measure back on each the distance of the point selected from the center of the crank pin. In this way a sufficient number of points will be obtained to construct the ellipse. In the accompanying diagram three points on the connecting rod were selected, one 6 inches from the center of the crosshead pin, another 2 feet, and a third $3\frac{1}{2}$ feet from the center of the crosshead pin. From the diagram it is perfectly plain that the major axis of the ellipses must be equal to the diameter of the crank circle, or in other words twice the throw of the crank, and for all practical purposes the minor axis lies between the lines representing the positions of the connecting rod for 90 degrees and 270 degrees on the crank circle, or between lines AB and AC. Then the end D of the minor axis lies on the hypotenuse AB of a right-angled triangle, this hypotenuse being the length of the crank, and the base of the triangle is equal to BO, or the throw of the crank. As the length of the connecting rod, the throw of the crank and the location of the point selected are always known, it is an easy matter to determine the length of DE, as the line DE would bear the same ratio to AD as BO does to AB. For instance, if the point selected was at the center of the connecting rod, DE would be just half of BO.

It is plain that DE is just half the minor axis of the ellipse, and multiplying by 2 will give the length of the minor axis. Having determined the length of



ELLIPTICAL PATH OF POINT ON CONNECTING ROD

the two axes, it is an easy matter to figure the circumference of the ellipse by means of the usual formulas. An approximate formula for the circumference of an ellipse is

$$3.1416 \sqrt{D^2 + d^2}, \qquad (1)$$

in which D^2 and d^2 represent the major and minor axes, respectively. A more accurate formula for the circumference of an ellipse is,

$$3.1416\sqrt{\frac{D^2+d^2}{2}-\frac{(D-d)^2}{8.8}} \quad (2)$$

When the major axis is more than five times as long as the minor axis the divisor 8.8 will not be large enough, and the following values should be substituted:

$$\frac{D}{d} = 6,\ 7,\ 8,\ 9,\ 10,\ 12.$$

$$Divisor = 9,\ 9.2,\ 9.3,\ 9.35,\ 9.4,\ 9.5.$$

In this particular case the point was given as 3 feet 5 inches from the center of the crosshead pin, so that the length of half the minor axis of the ellipse would be

$$\frac{41}{60}\times 9 = 6.15.$$

Multiplying this value by 2 would give 12.3 inches as the length of the minor axis, and, as the major axis is equal to the diameter of the crank circle, its length would be 18 inches. Taking the approximate formula (1) and substituting these values we obtain,

$$\frac{18^2+12.3^2}{2} = 48.38$$

inches, or a trifle over 4 feet. Any other point could be taken in the same way and readily solved, and for points over 6 inches from the center of the crosshead pin the results obtained would be very nearly accurate.

Lawrence Industrial School

The Lawrence (Mass.) Industrial School, which opened October 19 last, represents a new phase of technical education in Massachusetts, and is of interest to engineers in general, although designed primarily for increasing the efficiency of workers in the textile and metal trades. It has both day and evening courses, tuition being free, with no entrance examinations, the only restriction being that the student must be a shop or mill operative. The mechanical equipment of the school has already reached the value of $32,000.

Aside from the courses in textiles and industrial chemistry, one of the strongest departments of the school is the course in steam engineering and electricity. This course is provided with lectures by practical men skilled in their respective branches, with arithmetic and practical mathematics for engineers, firemen, etc., and laboratory practice in steam engineering. The laboratory equipment is excellent for giving a practical idea of the more common steam and electrical machines. The Lawrence school is under the immediate direction of William H. Dooley, and is the only independent industrial school in the State with a separate board of trustees and independent buildings. The purpose of the school is to provide training for students who could not assume the burdens of a four- or five-year course at a professional engineering college, either from the financial or preparatory standpoint. It is felt that the education received in the higher technical institutions does not entirely fill the needs of the industrial world, tending to create experts and administrators, while the rank and file of the industrial employees need a less severe curriculum, but one which will increase their usefulness and individual prospects notwithstanding the more elementary character of instruction which they can assimilate. There are nearly 1000 students.

Chemical Analysis of Pocahontas and New River Coals

The United States Geological Survey has just issued Bulletin 362, dealing with "Mine Sampling and the Chemical Analyses of Coals Tested at the Fuel Testing Plant at Norfolk, Va., in 1907." Advantage was taken of the proximity of this plant to the Pocahontas and New River fields for testing a large number of samples of these coals for use under boilers, in gas producers and in respect to their adaptability for briquets. The tests demonstrated that these coals could be formed into very satisfactory briquets, suitable for locomotive and marine use and strong enough to be shipped long distances.

The reports of the steaming investigations, the producer-gas tests, the briquet experiments, and the tests of liquid fuels in internal-combustion engines will form the subject of separate bulletins, to be issued at an early date. The present bulletin gives the particulars in detail of the collection and the analyses of a number of coals from these fields.

Water Power Plants for California Mines

On December 10 the new plant of the Great Western Power Company, at Las Plumas, on the Feather river, about 20 miles above Oroville, Butte county, was put in operation. Work has been going on there for several years, and many millions of dollars have been spent in construction and machinery. It is supposed that this is the largest electric generating plant in the world, as it will produce 144,000 horsepower. The whole river has been turned through the three-mile tunnel, gaining a fall of 75 feet, and at the lower end of the tunnel there is a drop of 540 feet to the power house. The entire tunnel is lined with concrete and smoothly finished inside. An old mining tunnel was utilized, extended and widened for this purpose. There are eight generators of 18,000 horsepower, four of which will be put in operation next month. The new Cowell cement works in Contra Costa county, 150 miles distant, started at once as soon as this electric power was turned on. The power will not only be furnished to mines, but small towns and to the cities of Oakland and San Francisco. This new plant is nearly five times as large as that of the California Gas and Electric station at Electra, heretofore the largest in the State.

The Northern California Power Company, which already has three large electric plants in operation, has commenced work on a fourth one, on Battle creek, in the Manton district, Tehama county. Owing to the difficulty of hauling in steel pipe, a boiler and machine shop is being built on the site of the power plant where the pipe will be manufactured. The water of several irrigating ditches will be added to the waters of Battle creek to furnish an adequate supply for the new power plant.—*Engineering and Mining Journal.*

Brooklyn Engineers' Club Dinner

The twelfth annual dinner of the Brooklyn Engineers' Club, held December 10, at the Brooklyn Germania club, was noteworthy for the first public appearance since his election of the new president of the Massachusetts Institute of Technology, Dr. Richard C. Maclaurin. Dr. Maclaurin spoke on the "Educational Problem" and discussed the teaching of basic principles and their importance in relation to details of practice. He deplored the tendency to neglect principles in favor of details of practice. Practice was ever changing in its detail and without the underlying principles was narrowing, and in the end likely to leave the engineer without ideas or ability to adapt himself to new conditions.

The toastmaster was Dr. George C. Wipple, retiring president of the club, and the other speakers were George W. Tillson, engineer of highways, Borough of Manhattan, Dr. W. T. Ledgwick, professor of biology, Massachusetts Institute of Technology, Andrew McLean, editor of the *Brooklyn Citizen*, and J. C. Meem, the new president of the Brooklyn Engineers' Club.

Internal Combustion Engineers' Association

The Internal Combustion Engineers' Association was formed in Chicago recently, and while it is at present largely confined to Chicago, its constitution is drawn so broadly as to allow it to become national or even international. The object of the association is the advancement in the broadest sense, and in every possible legitimate manner, of the interests of internal-combustion engineers. It is not a fraternal or union organization, but it does anticipate concerted efforts to bring

all into closer touch. It also intends to help the best men to get the best jobs, to help the best employers to get the best men, to help the owners and operators of gas-engine plants to get more reliable and efficient service from their equipment; also to help the manufacturers of gas-engine equipment toward a greater uniformity in detail of design, material and workmanship.

The organization has started with a good membership, in which the States of Ohio, Indiana, Illinois, Wisconsin, Iowa, Missouri and California are represented. The officers are: President, H. R. Linn, of Postel & Linn, consulting engineers; vice-president, I. J. Bent, chief engineer Illinois Steel Company; treasurer, I. J. Babcock, superintendent A. B. Dick Company; secretary, Walter A. Sittig, superintendent H. B. Rouse & Co.

A. I. E. E.

At the meeting of the American Institute of Electrical Engineers, on Friday evening, December 11, the paper of W. S. Murray, electrical engineer, of the New York, New Haven and Hartford Railroad Company, on "The Log of the New Haven Electrification," was presented and discussed by Messrs. Townley, Wilgus, Lamme, Stillwell, Armstrong, Storer, Katté, Davis, Tarchio, McClellan and Steinmetz. The paper covered the various difficulties in the installation and operation of the single-phase traction system, together with a statement of train delays and their causes during the months of July to October, 1908, inclusive. There was very little actual discussion of the paper, the old question of third-rail direct-current system *versus* the single-phase alternating system apparently being the main question in the minds of the speakers.

Anniversary of Mass. No. 1, N. A. S. E.

Massachusetts Association No. 1, National Association of Stationary Engineers, celebrated its twenty-seventh anniversary on Thursday, December 10, at Engineers hall, Boston, Mass. Besides a large attendance from the local associations there were delegations from Lowell and Haverhill. A most enjoyable evening was spent. Among the speakers were T. N. Kelsey, E. H. Kearney, James Duncan, O. B. Peterson, J. H. Sumner, William Sennott and P. E. Tyrill. During the evening, Columbus Dill and Messrs. Abbott and Doherty entertained, the performance concluding with a series of motion pictures, after which refreshments were served. The event was a pronounced success and reflects credit upon Messrs. Hayes, Duncan, Mullin and McFadel, who comprised the committee.

Elm City Association No. 10

Saturday evening, December 12, at the rooms of Elm City Association No. 10, N. A. S. E., of New Haven, there was a very able and interesting lecture on "Refrigeration," by Willis A. Lawrence, of New York City. The lecture was illustrated by lantern slides. Several associations from out of town, including Meriden No. 1, New Haven No. 2, Bridgeport No. 4 and Ansonia No. 11, were represented.

In addition to the lecture, there were remarks by George A. Cleveland, State vice-president; William J. Schatz, C. D. Osborn, E. J. Maroney, Patrick Grace, W. H. Wakeman and Professor Lockwood, of the Sheffield Scientific School of Yale college. Altogether, it was a memorable meeting. The next lecture will be given by J. J. McManus, on "Electricity," before Bridgeport No. 4, the fourth Friday in January.

Modern Science Club Announcements

The following announcements for January have been issued by the Modern Science Club, of Brooklyn: January 5, lecture on "Storage Batteries," by E. Van Wagenen; January 9, talk on whaling in the Arctic seas; January 12, paper on "The Quality of Fire," by J. A. Caldwell; January 19, lecture on "Electricity from the Transformer to the Consumer," by A. Wohlgemuth; January 23, paper on "Miniature Steam Traps and Their Application to Steam Circulation," by James A. Donnelly; January 26, lecture on "Compression in Steam Engine Cylinders," by F. L. Johnson; January 30, ladies' night, illustrated lecture on "Flags of All Nations."

On January 16 and 23 entries will be received for a handicap pool tournament.

The *Transactions* of the National Association of Cotton Manufacturers, containing the proceedings of the annual meeting held at Boston in April last, has just appeared. The contents, although dealing for the most part with textile subjects, comprise a number of papers of interest to power users, such as: "Economic Possibilities of Good Lubrication with the Results of Twenty Power Tests," by William F. Harris, Jr., of Vienna; "Belts and Belt Transmission," by Charles F. Chase, of New York; "Steam Turbines for Textile Mill Power," by Milden H. Merrall, of Boston; "Some Things a Manufacturer Should Know about Coal," by E. G. Bailey, of Boston.

A recently issued census-bureau pamphlet, entitled "Forest Products," No. 7, and treating of Wood Distillation, says that during 1907 the wood-distillation industry passed through its first year's experience under the working of the so-called denatured alcohol law. While this law had no disturbing influence on the value of such products as charcoal and acetate, the effect upon the price of wood alcohol was immediate and striking, the average value per gallon falling from 34 cents in 1906 to 15 cents in 1907.

On December 9 the National Gas and Gasolene Engine Trades Association was formed at Chicago, Ill., chiefly to promote the interests of the industry. The officers are: President, Harry T. Wilson, Middletown, O.; first vice-president, M. A. Loeb, Cincinnati, O.; treasurer, Otto M. Knoblock, South Bend, Ind.; secretary, Albert Stritmatter, Cincinnati, O. About 60 persons attended the initial meeting. The next meeting will be held at Chicago the first Tuesday in February.

An invitation smoker and reunion was given by the United Standard Mutual Benefit Association of Engineers at the Plaza assembly rooms, New York, on Thursday evening, December 17. Interesting addresses were made by Messrs. Hammel and Farrell, and an enjoyable entertainment was given by John Lloyd Wilson, William Murray, Charles Thompson, Henry Elder and Jack Armour. Refreshments were served.

The annual meeting of the Northwestern Electrical Association will be held at the Hotel Pfister, Milwaukee, January 20 and 21. An address will be made by Professor Meyer, of the Wisconsin Railroad Commission, and there will be live discussions on rates and rulings of the commission, tungsten lamps and other interesting topics.

Personal

Hubert E. Collins has been appointed vice-president and general manager of the Engineering Supervision Company, 43 and 45 West Thirty-fourth street, New York City, taking full charge of the operating force in the various plants controlled by this company.

George A. Orrok, of the New York Edison Company, spoke before the "Tech" club on Saturday evening, November 5, upon "The Romance of Engineering." Mr. Orrok brought out strongly the poetical and romantic side of the engineer's achievements, and provided for his hearers an interesting and instructive half hour.

Meeting of the A. S. M. E.

The next monthly meeting of the American Society of Mechanical Engineers will be held in the Engineering Societies building, New York City, on Tuesday evening, January 12. The paper will be by Carl G. Barth, of Philadelphia, upon "The Transmission of Power by Leather Belting," illustrated by lantern slides. It will be a comprehensive summing up of the theory and practice of belting, in which conclusions are drawn from the work of Lewis, Bancroft, Bird and others, who have made experiments upon the transmission of power by belting. Valuable charts have been prepared by the author for the solution of belting problems.

Business Items

A handsome and useful 12-inch ruler is being distributed by the Wilpaco Packing Company, 109 Liberty street, New York. It is of wood, with the divisions on a white background, making it very easily read. A metal paper cutter is also attached.

J. I. Wile, sales manager of the producer department of the Gas Machinery Company, of Cleveland, Ohio, will make his headquarters at the New York office, 56 Pine street, after January 1. The Gas Machinery Company now has the exclusive rights for building the Wile gas producer, many of which are operating in New York and vicinity.

The Yale & Towne Manufacturing Company, 9 Murray street, New York City, has just issued a 70-page 6x9-inch catalog devoted to its lines of chain blocks, electric hoists, trolleys and cranes. Each is comprehensively described and illustrated, and such helps as may be needed, such as tables of dimensions, etc., are also included.

The growing demand for Bird-Archer boiler compounds in Hawaii has made it necessary for the Bird-Archer Company to open a branch office there. The new office, which is located in Suite 42, Alexander Young hotel, Honolulu, is in charge of J. P. Lynch, an experienced marine engineer, who is also an authority on boiler troubles in stationary plants. Bird-Archer compounds were first introduced into Hawaii for use in connection with the boilers on sugar plantations, a class of work for which it is also used in Cuba. P. B. Bird, president of the company, who is now in Hawaii, writes that boiler feed waters on the islands are so bad that if no preventive measures are employed it becomes necessary to remove scale by mechanical methods at least once every thirty days.

The Pacific Mills, of Lawrence, Mass., have recently placed orders through Charles T. Main, designing engineer, for additional power-house equipment, as follows: With the Allis-Chalmers Company for a steam turbine, with turbo jet condenser and generator of 3250-kilowatt capacity, and additional exciter and switchboard apparatus; with the Bigelow Company for twelve additional horizontal return-tubular boilers, of practically the same size as those contained in the first installation. These boilers will be supplied with superheaters. The buildings are of sufficient size to contain all of this new apparatus, which completes the unit of station which has been planned for and built. Another chimney will be built of the same size as the one recently erected, namely 200 feet high and 9 feet diameter inside the core.

Schuchardt & Schutte, constituting the well-known machinery house of Berlin, Vienna, Stockholm, St. Petersburg, Copenhagen, Budapest, London, New York and Shanghai, announce that they have opened a branch under their own name for the sale of machine tools, woodworking machines and small tools at No. 14 Akashicho Tsukiji, Tokio, Japan. While Schuchardt & Schutte has been closely affiliated for several years with the machine-tool trade in Japan, through its direct representatives, the establishment of a branch selling organization is a further step in the expansion of the export trade in American machine tools with which this firm has been so directlyi dentified. The Tokio branch is under the management of James G. Brown, who has spent several years in the Far East in the interests of this firm.

Under date of December 11, 1908, the Michigan Lubricator Company, of Detroit, Mich., received a lubricator from Gannon & Carey, of Erie, Penn., with a letter which reads as follows: "We are expressing you today by American Express Company one of your lubricators, which we would ask you to put in first-class order and return to us at once. Thanking you for your prompt attention, we are, yours respectfully, Gannon & Carey." The lubricator was duly received, and it was found that it was numbered 311, manufactured by the Michigan Lubricator Company in December, 1884, being one of the first lubricators which they ever manufactured. It is in good shape and with the exception of replacing a glass and a new feed stem will be as good as the day it left their factory. The fact that twenty-five years ago they were manufacturing a lubricator that would stand the wear and tear of an engine room, heat and cold, is sufficient evidence of the workmanship and material in the Michigan product.

Dr Schuyler Skaats Wheeler, past president of the American Institute of Electrical Engineers, and president of the Crocker-Wheeler Company, of Ampere, N. J., recently gave out the following interview: "It is not reasonable to expect that business will immediately return to normal merely because the outlook at the present time is bright. A complete resumption of business cannot occur rapidly, and it may be months before conditions in the business world are what they were before the financial panic of a year ago. However, every feature of the situation is favorable at the present time. Factories are starting up, more men are being employed, and there is a better market than there has been for fourteen months for all kinds of machinery. I am looking forward, during 1909, to a complete recovery, and more and better business than we have yet had. At this time those companies like the Crocker-Wheeler Company, which have at great expense retained their organizations and personnel, including highly trained designing and sales engineers, during the lean months of 1908, are now reaping the benefit of this policy and are in a position to go forward faster and with greater effect than is possible for the concerns that have had obliged, through forced economy, to reduce their organizations and discharge many of their good men."

The Westinghouse Electric and Manufacturing Company has again become the property of the stockholders, after having been in the hands of receivers since October 23, 1907. The petition for the discharge of the receivers was made on December 5 in Pittsburg, before Judge Young, of the United States District Court of the Western Circuit of Pennsylvania, and was immediately signed by him. The petition was presented by G. B. Gordon, attorney for the receivers and for the Merchandise Creditors' Committee; Paul D. Cravath, attorney for the Stockholders' Committee, and A. H. Larkin, attorney for the Readjustment Committee. Mr. Gordon made the address to the court, in which he gave a statement of the company's affairs prior to the receivership, explained the causes which led to the establishment of the receivership, presented a report of the operation of the company during the tenure of the receivership, and finally led up to the great work which has been accomplished within so short a time by Mr. Westinghouse and the various committees in bringing about the rehabilitation and reorganization of the company. He emphasized the fact that during the year the receivers had been in charge, they had not only succeeded in paying off the interest on bonds, as it fell due from time to time, but that they also kept the large factories of the company in operation during the entire time, doing an excellent business at a net profit of over $1,000,000. The action of 5000 employees subscribing for $600,000 of stock of the company was another feature presented to the court, which made a great impression, because it demonstrated the amount of confidence the employees themselves had in the company. It was also brought out that the company under the reorganization would in every way be in a better condition than at any previous period in its history, as it would start upon the new régime with cash on hand amounting to upward of $15,000,000, with an indebtedness of only about $200,000. Mr. Cravath, in addressing the court on behalf of the Stockholders' Committee, stated that in the annals of receiverships, this one stood without a parallel as the most successful. The board of directors, which consists of George Westinghouse, E. M. Herr, James S. Kuhn, Joseph W. Marsh, William McConway, J. L. Callery, Richard Delafield, Albert H. Wiggin, Charles S. Brooker, A. G. Becker, Charles A. Moore, Edwin F. Atkins, Neal Rantoul, E. C. Converse, Anthony N. Brady and George Verity, held a meeting in New York, Monday, December 7, and organized as follows: President, George Westinghouse, temporary chairman of executive committee, E. C. Converse; first vice-president, E. M. Herr; second vice-president, L. A. Osborne; acting vice-presidents, G. W. Hebard and W. M. McFarland; secretary, Charles A. Terry; treasurer, T. W. Siemon; assistant treasurer, E. St. John and H. F. Baetz; auditor, J. C. Bennett.

New Equipment

City of Carterville, Mo., will construct water-works. L. M. Jones, mayor.

The American Ice Company, Philadelphia, Penn., will erect a new plant.

The Syracuse (N. Y.) Cold Storage Company will erect a seven-story storage plant.

City of Delhi, La., is considering construction of electric-light plant and water-works.

John P. Holmes, Eldorado, Ark., has been granted franchise to construct a water-works system.

The town of Joliet, Mont., will construct power plant and water-works at a cost of about $50,000.

The city of Terrell, Texas, is having plans prepared for electric-light plant. E. R. Miller, secretary.

The Rocky Mount (N. C.) Ice Company will increase output of plant and erect a new storage warehouse.

The plant of the Olney (Ill.) Electric Light and Power Company was destroyed by fire. Loss, $24,000.

The city of Jellico, Tenn., is having plans and specifications prepared for water-works. S. B. Snyder, mayor.

The Suwanee River Railway and Power Company will soon begin construction of power plant near White Springs, Fla. D G. Ziegler & Co., care of Suwanee River Railway and Power Company, Jacksonville, Fla., are engineers in charge.

Keep This Name In Mind:

American Steam Gauge & Valve Mfg. Company

It Stands For The Best In Engineering Specialties

It wouldn't pay us to make cheap goods, because it wouldn't pay you to buy them.

That's the real reason why we have always kept our standard up to the highest possible point.

We're glad we don't have to make cheap articles. We're glad you can't afford to use them—and we're also glad to be the firm that America's most discriminating engineers turn to when they need high grade specialties.

The best in any line is pretty sure to be cheapest in the end, and from that point of view American Specialties are the cheapest made.

Try them and you'll see the importance of our principle.

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Los Angeles, 213 So. Los Angeles Street.

When ordering gauges, valves, indicators, and kindred appliances for governing, indicating, measuring, recording and controlling steam, air, gas, oil, ammonia and all other pressures, be sure to specify those manufactured by us. Your interests can be best served by the protection they afford.

New Catalogs

Termaat & Monahan Co., Oshkosh, Wis. Catalog. Marine engines. Illustrated, 64 pages, 6x9 inches.

Geo. H. Thacher & Co., Albany, N. Y. Catalog. Coe shaking and dumping grate. Illustrated, 6x9 inches.

B. F. Sturtevant Company, Hyde Park, Mass. Bulletin No. 158. Our New Product. Illustrated, 16 pages, 6½x9 inches.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

SALESMEN WANTED to sell a high-grade steam specialty. Must be competent. Address P. O. Box 467, Altoona, Pa.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

WANTED—By prominent engineering house on the North Pacific coast, a practical mechanical draftsman. One acquainted with power plant design preferred. Splendid opening for one who is in earnest. Address, giving full particulars as to qualifications, salary wanted, etc. Box 65, POWER.

AGENTS to sell one of the best known and widely advertised shaking grates on the market. Exclusive territory granted to anyone who can make good. Liberal commission. Perfection Grate Co., Box 1081, Springfield, Mass.

DESIGNER WANTED—First class man on gas or steam engines in the medium powers. Practical man with shop or operating experience, capable of developing new ideas on drafting board. Permanent position with large New York City firm to the right party. State detailed experience, age and salary. Address, "Large Firm," Box 75, POWER.

WANTED—Two pump draftsmen with wide experience on direct-acting and fly-wheel pumping engines and air compressors; those with technical education preferred. Address, "Pump," Box 76, POWER.

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Advertisements under this head are inserted for 25 cents per line. About six words make a line.

SALESMAN — ENGINEER — Power and transmission equipment. Specialist in pumping machinery. No contract wanted until ability is fully demonstrated. Eighteen years' experience. Box 73, POWER.

Miscellaneous

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PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-examiner, U. S. Patent Office, McGill Bldg., Washington, D. C

INDICATOR CARDS worked out, $1.00 each. Strictly confidential; any question answered. R.P.M., pressure, spring, engine size, make, etc. Indicating Co., 58–Perin Bldg., Cincinnati, Ohio.

DRAFTSMEN—Change your T-square to a parallel device; $2.50. F. G. Hobart, Beloit, Wis.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—Direct-connected engine and generator. 100 kw.; direct current; good as new. Address Monarch Machine Works, Altoona, Pa.

FOR SALE—20x48 Wheelock engine and two 72″x18′ high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

FOR SALE—20″x42″ improved Greene engine. Wheel 32″x14′. Used seven years. Also 24″x48″ improved Greene engine. Wheel 42″x16′. Used eight years. Both engines in first class shape. Can be seen running. The Capewell Horse Nail Co., Hartford, Conn.

DEAN BROS. SIMPLE PISTON VALVE pump, 5¼″x3¾″x7″. Used three weeks; bargain. Owensville Light Co., Owensville, Indiana.

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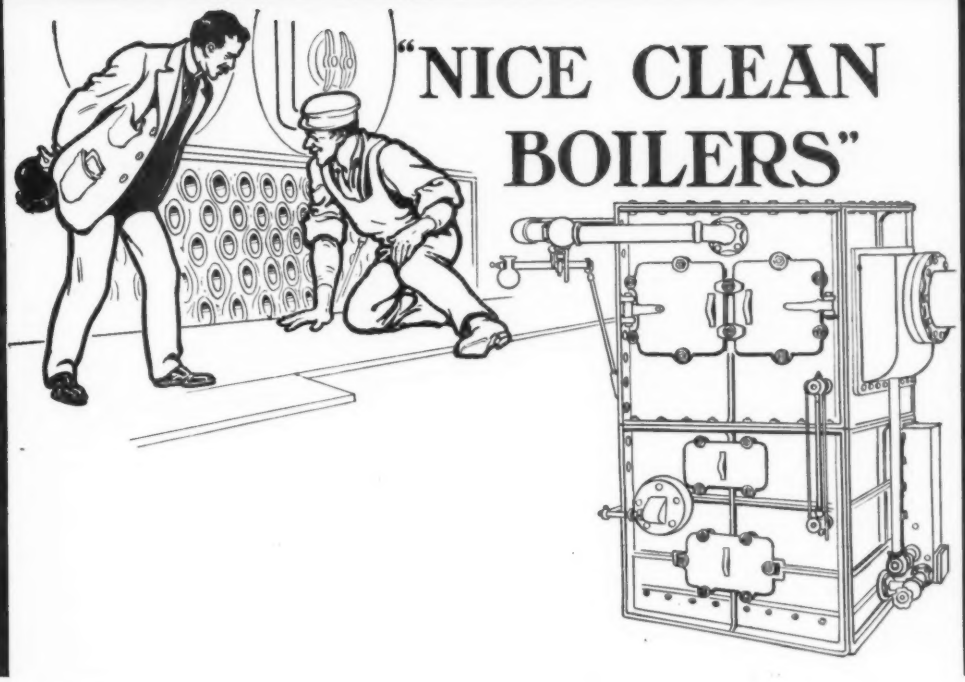
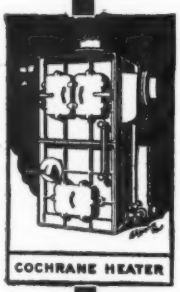


"NICE CLEAN BOILERS"

"NICE, CLEAN BOILERS" make both the Engineer and the Owner good natured. Where our "HOT PROCESS SYSTEM" of WATER PURIFICATION is used there is no heavy, dirty work of hammering hard scale off boiler shells or of boring it out of boiler tubes. The boilers need fewer repairs, since they are not damaged by corrosion, nor by temperature strains due to the introduction of cold feed water or to accumulations of sludge or scale on the heating surfaces. It is not necessary to force some of the boilers in order to lay others off for cleaning. There are no annoying "desperation" shut-downs for cleanings that cannot be longer postponed, nor for repairs that have become imperatively necessary.



The Engineer likes our "Hot Process System" because it is easily understood; only one chemical to feed and no complicated chemical analysis to make. The apparatus is easy to clean; just take off the doors and shovel out the accumulations of deposit. Then, too, the feed of the chemical is automatic, just as needed.

The Owner likes our system because it heats the boiler feed water as well as purifies it, saving the expense of buying caustic lime, and also saving about 16% of the coal bill. He knows that his boilers are being protected from corrosion, since all acids are completely neutralized in our system, while corrosive gases and air are driven off to the atmosphere. Besides, our apparatus saves the buying of a whole lot of auxiliaries, such as return and expansion tanks, independent oil separators, traps, pumps and receivers, feed water filters, skimming tanks and the complex piping and many joints and fittings required for the installation of all these devices.

Tell us your conditions and we shall be pleased to explain all about it.

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Westinghouse Machine Co., Pittsburg, Pa.

Belt Fasteners

Bristol Company, Waterbury, Conn.

Belting, Leather

Garlock Packing Co., Palmyra, N. Y.
N. Y. Belting & Packing Co., New York.
Reeves Pulley Co., Columbus, Ind.
Restein Co., Clement, Philadelphia, Pa.
Rhoads & Sons, J. E., Phila., Pa.
Robins New Conveyor Co., New York.
Sawyer Belting Co., New York.
Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.

Belting, Rubber

Diamond Rubber Co., Akron, Ohio.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.

Benders, Hydraulic

Watson-Stillman Co., New York.

Bending, Pipe

Harrisburg Pipe & Pipe Bending Co., Harrisburg, Pa.
National Pipe Bending Co., New Haven, Conn.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Bends, Pipe

Harrisburg Pipe and Pipe Bending Co., Harrisburg, Pa.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Bends, Pipe—*Continued.*

Whitlock Coil Pipe Co., Hartford, Conn.

Blocks, Chain

Yale & Towne Mfg. Co., New York.

Blowers

Beggs & Co., James, New York
De Laval Steam Turbine Co., Trenton, N. J.
Green Fuel Economizer Co., Matteawan, N. Y.
McClave-Brooks Co., Scranton, Pa.
Ohio Blower Co., Cleveland, O.
Sirocco Engineering Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Wing Mfg. Co., L. J., New York.

Blowers, Furnace

McClave-Brooks Co., Scranton, Pa.

Boilers

Babcock & Wilcox Co., New York.
Beggs & Co., James, New York.
Berry Engineering Co., Chester, Pa
Edge Moor Iron Co., Edge Moor, Del.
Erie City Iron Wks., Erie, Pa.
Griffith & Wedge Co., Zanesville, O.
Heine Safety Boiler Co., St. Louis, Mo.
Keeler & Co., E., Williamsport, Pa.
Kewanee Boiler Co., Kewanee, Ill.
Morrin Climax Boiler Co., Brooklyn, N. Y.
Oil Well Supply Co., Oswego, N. Y.
Parker Boiler Co., Philadelphia, Pa.
Phoenix Iron Works Co., Meadville, Pa.
Robb-Mumford Boiler Co., South Framingham, Mass.
Struthers-Wells Co., Warren, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Vogt Machinery Co., Henry, Louisville, Ky.
Wetherill & Co., Robert, Chester, Pa.
Wickes Boiler Co., Saginaw, Mich.

Boilers, Second Hand

Wickes Boiler Co., Saginaw, Mich.

Books

American School of Correspondence, Chicago, Ill.
Hill Publishing Co., New York.
International Text Book Co., Scranton, Pa.
System Co., Chicago, Ill.

Boosters

Ridgway Dynamo & Engine Co., Ridgway, Pa.

Brick, Fire

C-O-Two Furnace Co., Syracuse, N. Y.
McLeod & Henry Co., Troy, N. Y.
Presbrey Fire Brick Wks., Taunton, Mass.

Brick, Radial

Kellogg Co., M. W., New York.

Building Materials, Fireproof

Carey Co., Philip, Cincinnati, O.
Johns-Manville Co., H. W., New York.

Castings, Brass and Iron

Homestead Valve Mfg. Co., Pittsburg, Pa.
Illinois Malleable Iron Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Ohio Brass Co., Mansfield, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Castings, General

Neemes Bros., Troy, N. Y.

Castings, Malleable

Jeffrey Mfg. Co., Columbus, O.

Cement, Asbestos

Johns-Manville Co., H. W., New York.
N. Y. Belting & Packing Co., New York.

Cement, Boiler

Smooth-On Mfg. Co., Jersey City, N. J.

Chimneys, Reinforced Concrete

Wiederholdt Construction Co., Chicago, Ill.

Clamp, Steam Joint

McCrea & Co., James, Chicago, Ill.

Clamp, Pipe

McCrea & Co., James, Chicago, Ill.

Cleaners, Mechanical Tube

Andrews Mfg. Co., Thos., Rockaway, N. J.
Buckeye Boiler Skimmer Co., Toledo, Ohio.
Chesterton Co., A. W., Boston, Mass.
Garlock Packing Co., Palmyra, N. Y.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
McCrea & Co., James, Chicago, Ill.
Pierce Co., Wm. B., Buffalo, N. Y.
Robertson & Sons, Jas. L., New York.
Stewart Heater Co., Buffalo, N. Y.

Cleaners, Steam Flue

Henry Steam Flue Cleaner Co., Ashland, Wis.

Cleaners, Turbine Boiler Tube

Andrews Mfg. Co., Thos., Rockaway, N. J.
Lagonda Mfg. Co., Springfield, Ohio.

Clocks

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Standard Gauge Mfg. Co., Foxboro, Mass.

Clutches, Friction

Reeves Pulley Co., Columbus, Ind.
Williams Fdry. & Mach. Co, Akron, Ohio.

Cocks, Air

Williams Valve Co., D. T., Cincinnati, Ohio.

Cocks, Blow-Off

Liberty Mfg. Co., Pittsburg, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Cocks, Gage

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Chaplin-Fulton Mfg. Co., Pittsburg, Pa.
Huyette Co., P. B., Philadelphia, Pa.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Reliance Gauge Column Co., Cleveland, O.

Cocks, Steam

Homestead Valve Mfg. Co., Pittsburg, Pa.
Schutte & Koerting Co., Philadelphia, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Coils, Pipe

Fairbanks Co., New York.
National Pipe Bending Co., New Haven, Conn.

Compound, Boiler

Binghamton Boiler Compound Co., Binghamton, N. Y.
Bird-Archer Co., New York.
Buckeye Boiler Skimmer Co., Toledo, Ohio.
Coralline Drug & Chemical Co., New York.
Dearborn Drug & Chemical Co., Chicago, Ill.
Hawk-Eye Compound Co., Chicago, Ill.

Compound, Boiler—*Continued.*

Johns-Manville Co., H. W., New York.
Lagonda Mfg. Co., Springfield, Ohio.

Compound, Lubricating

Cook's Sons, Adam, New York.
Houghton & Co., E. F., Philadelphia, Pa.

Condensers

Alberger Condenser Co., New York
Anderson Co., V. D., Cleveland, O.
Baragwanath & Son, Wm., Chicago, Ill.
Deane Steam Pump Co., Holyoke, Mass.
Epping-Carpenter Co., Pittsburg, Pa.
Kellogg Co., M. W., New York.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Schutte & Koerting Co., Philadelphia, Pa.
Stewart Heater Co., Buffalo, N. Y.
Southwark Foundry and Machine Co., Philadelphia, Pa.
Wheeler Condenser and Engineering Co., New York.

Consumers, Smoke

Climax Smoke Preventer Co., Boston, Mass.

Controllers, Electric

General Electric Co., Schenectady, N. Y.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa

Controllers, Feed Water

American Boiler Economy Co., Philadelphia, Pa.

Cooling Apparatus, Air

De La Vergne Machine Co., New York.
Triumph Ice Machine Co., Cincinnati, Ohio.

Cooling Plants

Schutte & Koerting Co., Philadelphia, Pa.

Cooling Towers

Alberger Condenser Co., New York.
Baragwanath & Son, Wm., Chicago, Ill.
Wheeler Condenser and Engineering Co., New York.

Correspondence Schools

American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa,

Couplings, Clutch

Williams Fdry. & Mach. Co., Akron, Ohio

Covering, Pipe and Boiler

Carey Co., Philip, Cincinnati, O.
Houghton & Co., E. F., Philadelphia, Pa.
Johns-Manville Co., H. W., New York.
U. S. Mineral Wool Co., New York.
Wyckoff & Son Co., A., Elmira, N. Y.

Covering, Pulley

Houghton & Co., E. F., Philadelphia, Pa.

Crabs

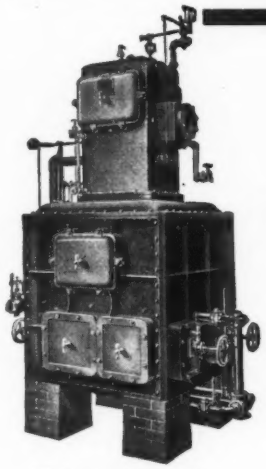
Yale & Towne Mfg. Co., New York.

Cranes

Yale & Towne Mfg. Co., New York.

Die Stocks

Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., Cleveland, O.



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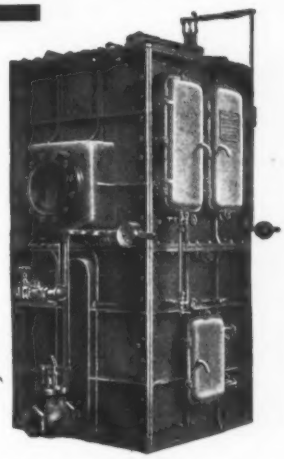
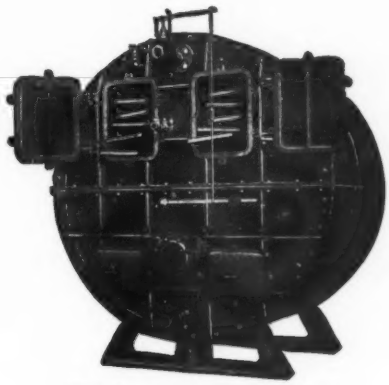
As Long As There's A Difference In Water There Must Be A Difference In Heaters



Webster Feed Water Heater, Purifier and Filter



Webster Feed Water Heater, Purifier and Filter

The Webster Plan

of feed water purifying and heating consists, first, in a thorough analysis of the water to be used; second, in a scientific prescription by our expert chemists; third, in an absolute guarantee that our heater will be so perfectly adapted to your individual requirements that pure water will be fed into the boilers at highest possible temperature; fourth, the installation of the Webster Heater or Chemical Purifier that is to do the work.

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CAMDEN, NEW JERSEY.

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Draft Apparatus, Mechanical

Green Fuel Economizer Co., Matteawan, N. Y.
Schutte & Koerting Co., Philadelphia, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Wing Mfg. Co., L. J., New York.

Dressing, Belt

Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Garlock Packing Co., Palmyra, N. Y.
Harris Oil Co., A. W., Providence, R. I.
Houghton & Co., E. F., Philadelphia, Pa.
Johnson Co., Henry, Jersey City, N.J.
Rhoads & Son, J. E., Phila., Pa.
Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.
Stephenson Mfg. Co., Albany, N Y.
Walton Co., F. S., Philadelphia, Pa.

Dressing, Rope

Cling-Surface Co., Buffalo, N. Y.

Drills, Upright

Barnes Co., W. F. & John, Rockford, Ill.

Dust Collectors

Sturtevant Co., B. F., Hyde Park, Mass.

Dynamos

American Engine Co., Bound Brook, N. J.
Clark Bros. Co., Belmont, N. Y.
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Electric Co., Cincinnati, O.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Educational

American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa.

Ejectors

American Injector Co., Detroit, Mich.
Beggs & Co., James, New York.
Lunkenheimer Co., Cincinnati, O.
Ohio Injector Co., Wadsworth, O.
Penberthy Injector Co., Detroit, Mich.
Schutte & Koerting Co., Philadelphia, Pa.

Engine Stops

Schutte & Koerting Co., Philadelphia, Pa.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Engineers and Contractors

Lammert & Mann, Chicago, Ill.

Engines, Blowing

Wisconsin Engine Co., Corliss, Wis.

Engines, Corliss

Bates Machine Co., Joliet, Ill.
Beggs & Co., James, New York.
Cooper Co., C. & G., Mt. Vernon, O.
Griffith & Wedge Co., Zanesville, O.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Providence Eng. Works, Providence, R. I.
Southwark Foundry and Machine Co., Philadelphia, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Wetherill & Co., Robert, Chester, Pa.
Wheeler Condenser & Engineering Co., New York.
Wisconsin Engine Co., Corliss, Wis.

Engines, Gas and Gasolene

Alberger Co., A. H., Buffalo, N. Y.
Beggs & Co., Jas., New York.
Buckeye Engine Co., Salem, Ohio.
De La Vergne Machine Co., New York.

Engines, Gas and Gasolene —*Continued.*

Du Bois Iron Works, Du Bois, Pa.
Fairbanks Co., New York.
Foos Gas Engine Co., Springfield, O.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Riverside Engine Co., Oil City, Pa.
Struthers-Wells Co., Warren, Pa.
Westinghouse Machine Co., Pittsburg, Pa.
Wisconsin Engine Co., Corliss, Wis.

Engines, Hoisting

Wisconsin Engine Co., Corliss, Wis.

Engines, Oil

De La Vergne Machine Co., New York.
Du Bois Iron Works, Du Bois, Pa.

Engines, Rolling Mill

Wisconsin Engine Co., Corliss, Wis.

Engines, Rotary

Ball-Cooley Engineering Co., New York.

Engines, Steam

American Engine Co., Bound Brook, N. J.
Ball Engine Co., Erie, Pa.
Ball & Wood Co., Elizabethport, N. J.
Bates Machine Co., Joliet, Ill.
Beggs & Co., Jas., New York.
Buckeye Engine Co., Salem, Ohio.
Clark Bros. Co., Belmont, N. Y.
Cooper Co., C. & G., Mt. Vernon, Ohio.
Erie City Iron Wks., Erie, Pa.
Erie Mfg. & Supply Co., Erie, Pa.
Fitchburg Steam Eng. Co., Fitchburg, Mass.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Phoenix Iron Works Co., Meadville, Pa.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Rollins Engine Co., Nashua, N. H.
Shepherd Engineering Co., Williamsport, Pa.
Skinner Engine Co., Erie, Pa.
Southwark Foundry & Machine Co., Philadelphia, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Westinghouse Machine Co., Pittsburg, Pa.
Wisconsin Engine Co., Corliss, Wis.

Exhaust Heads

Burt Mfg. Co., Akron, O.
Gardner Gov. & Separator Co., Quincy, Ill.
Hoppes Mfg. Co., Springfield, O.
Ohio Blower Co., Cleveland, O.
Patterson & Co., F. L., New York.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Whitlock Coil Pipe Co., Hartford, Conn.

Fans, Electric

Crocker-Wheeler Co., Ampere, N. J.
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Electric Co., Cincinnati, O.
Westinghouse Elec. and Mfg. Co., Pittsburg, Pa.

Fans, Exhaust and Ventilating

Anderson Co., V. D., Cleveland, Ohio.
Ohio Blower Co., Cleveland, O.
Sirocco Engineering Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.

Fans, Ventilating, Mine

Jeffrey Mfg. Co., Columbus, O.

Feeders, Boiler

American Boiler Economy Co., Philadelphia, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
Lunkenheimer Co., Cincinnati, O
Myers & Bro., F. E., Ashland, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Filters, Feed Water

Beggs & Co., James, New York.
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Keystone Chemical Co., Philadelphia, Pa.

Filters, Oil

Beggs & Co., Jas., New York.
Burt Mfg. Co., Akron, O.
Houghton & Co., E. F., Philadelphia, Pa.
Liberty Mfg. Co., Pittsburg, Pa.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Standard Gauge Mfg. Co., Foxboro, Mass.

Filtration and Softening Plants

Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Harrison Safety Boiler Wks., Philadelphia, Pa.

Fittings, Ammonia

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
De La Vergne Machine Co., New York.
Triumph Ice Machine Co., Cincinnati, O.
York Mfg. Co., York, Pa.

Fittings, Boiler

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Schutte & Koerting Co., Philadelphia, Pa.

Fittings, Flange

Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Pittsburgh Valve & Fittings Co., Barberton, O.
Pittsburgh Valve, Foundry & Construction Co., Pittsburg, Pa.

Fittings, Hydraulic

Watson-Stillman Co., New York.

Fittings, Pipe

Fairbanks Co., New York.
Kellogg Co., M. W., New York.
Ohio Brass Co., Mansfield, O.
Triumph Ice Machine Co., Cincinnati, Ohio.

Flanges, Malleable Iron

Illinois Malleable Iron Co., Chicago, Ill.
Jefferson Union Co., Lexington, Mass.

Flanges, Welded

Ball & Wood Co., Elizabethport, N. J.
Kellogg Co., M. W., New York.

Floats

Anderson Co., V. D., Cleveland, O.
Reliance Gauge Column Co., Cleveland, O.
Schutte & Koerting Co., Philadelphia, Pa.

Flue Gas Analysis Instruments

Pierce Co., Wm. B., Buffalo, N. Y.

Forges

Sturtevant Co., B. F., Hyde Park, Mass.

Fuel Economizers

Green Fuel Economizer Co., Matteawan, N. Y.
Sturtevant Co., B. F., Hyde Park, Mass.

Furnace Tile

C-O-Two Furnace Co., Syracuse, N. Y.

Furnaces, Automatic

Murphy Iron Works, Detroit, Mich.

Furnaces, Forging

Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Furnaces, Smokeless

McClave-Brooks Co., Scranton, Pa.
Murphy Iron Works, Detroit, Mich.
Wilkinson Mfg. Co., Bridgeport, Penn.

Gage Boards

American Steam Gauge & Valve Mfg. Co., Boston, Mass.

Gage Glasses

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Chesterton Co., A. W., Boston, Mass.
Garlock Packing Co., Palmyra, N. Y.

Gage Testing Outfit

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Gages, Ammonia

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

Gages, Draft

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.

Gages, Pressure

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Ashton Valve Co., Boston, Mass.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Standard Gauge Mfg. Co., Foxboro, Mass.

Gages, Recording

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Ashton Valve Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Standard Gauge Mfg. Co., Foxboro, Mass.

Gages, Steam

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Gages, Vacuum

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Bristol Co., Waterbury, Conn.
Crosby Steam Gage & Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co. Pittsburgh, Pa.
Schutte & Koerting Co., Philadelphia, Pa.
Standard Gauge Mfg. Co., Foxboro, Mass.

Gages, Water

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Huyette Co., Paul B., Philadelphia, Pa.
Lunkenheimer Co., Cincinnati, Ohio.
Ohio Brass Co., Mansfield, O.

Gas Producers

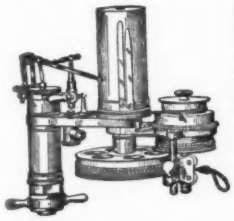
De La Vergne Machine Co., New York.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Westinghouse Mach. Co., Pittsburg, Pa.

Gaskets, Copper

American Goetze-Gasket & Packing Co., New York.
Restein Co., Clement, Philadelphia, Pa.
U. S. Mineral Wool Co., New York.

Gaskets, Leather

Brandt, Randolph, New York.
Garlock Packing Co., Palmyra, N. Y.
Houghton & Co., E. F., Philadelphia, Pa.
Jenkins Bros., New York.
Johns-Manville Co., H. W., New York.
Johnson Co., Henry, Jersey City, N. J.
N. Y. Belting & Packing Co., New York.
Smooth-On Mfg. Co., Jersey City, N. J.
U. S. Mineral Wool Co., New York.



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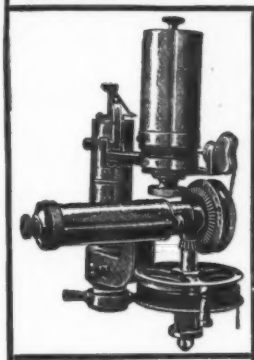

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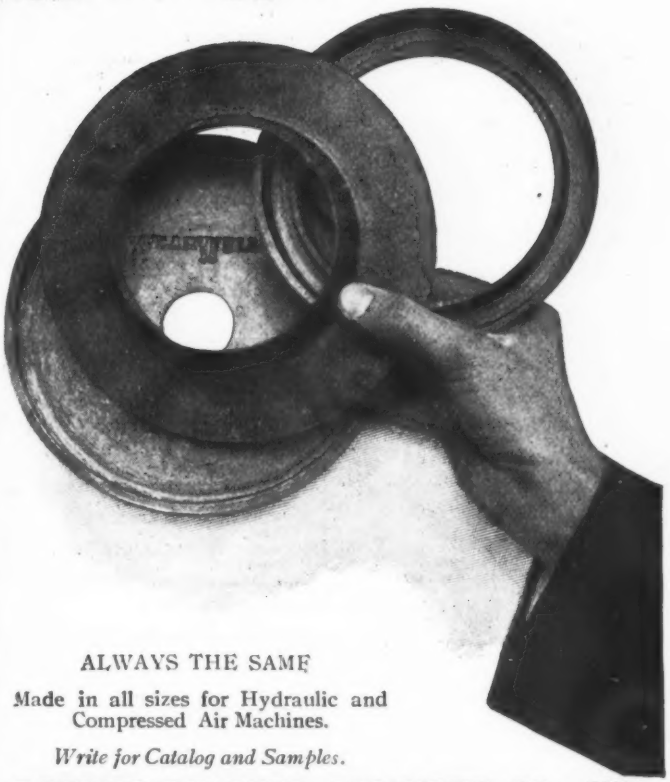

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Quaker City Rubber Co., Philadelphia, Pa.

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Crocker-Wheeler Co., Ampere, N. J.
Foos Gas Engine Co., Springfield, Ohio.
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Skinner Engine Co., Erie, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Generating Units

Ridgway Dynamo & Engine Co., Ridgway, Pa.

Governors, Pump

American Boiler Economy Co., Philadelphia, Pa.
Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Pittsburg, Pa.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
d'Este Co., Julian, Boston, Mass.
Fisher Governor Co., Marshalltown, Iowa.
Gardner, Governor & Separator Co., Quincy, Ill.
Strong, Carlisle & Hammond Co., Cleveland, O.

Graphite

Carpenter & Co., W. D., New York.
Dixon Crucible Co., Jos., Jersey City, N. J.
Garlock Packing Co., Palmyra, N. Y.

Grate Bars

Erie City Iron Wks., Erie, Pa.
Salamander Grate Bar Co., New York.

Grates, Chain

Babcock & Wilcox Co., New York.
Green Engineering Co., Chicago, Ill.

Grates, Clinker Crushing

Neemes Bros., Troy, N. Y.
Salamander Grate Bar Co., New York.

Grates, Dumping

Salamander Grate Bar Co., New York.

Grates, Rocking

Salamander Grate Bar Co., New York.

Grates, Shaking and Dumping

McClave-Brooks Co., Scranton, Pa.
Martin Grate Co., Chicago, Ill.
Neemes Bros., Troy, N. Y.
Salamander Grate Bar Co., New York.

Grates, Stationary

Neemes Bros., Troy, N. Y.
Salamander Grate Bar Co., New York.

Grates, Stationary and Dumping, Combined

Salamander Grate Bar Co., New York.

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Cook's Sons, Adam, New York.
Harris Oil Co., A. W., Providence, R. I.
Houghton & Co., E. F., Philadelphia, Pa.
Keystone Lubricating Co., Philadelphia, Pa.

Grease Cups

See Oil and Grease Cups.

Grease Extractors

Beggs & Co., Jas., New York.

Heaters and Purifiers, Feed Water

Alberger Condenser Co., New York.
Baragwanath & Son, Wm., Chicago, Ill.

Heaters and Purifiers, Feed Water—*Continued.*

Bates Machine Co., Joliet, Ill.
Buckeye Boiler Skimmer Co., Toledo, Ohio.
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Erie City Iron Wks., Erie, Pa.
Erie Mfg. & Supply Co., Erie, Pa.
Griscom-Spencer Co., New York.
Harrison Safety Boiler Wks., Philadelphia, Pa.
Harrisburg Pipe and Pipe Bending Co., Harrisburg, Pa.
Hoppes Mfg. Co., Springfield, O.
Kewanee Boiler Co., Kewanee, Ill
Loew Mfg. Co., Cleveland, O.
National Pipe Bending Co., New Haven, Conn.
Patterson & Co., F. L., New York.
Schutte & Koerting Co., Philadelphia, Pa.
Stewart Heater Co., Buffalo, N. Y.
Webster & Co., Warren, Camden, N. J.
Wheeler Condenser and Engineering Co., New York.
Whitlock Coil Pipe Co., Hartford, Conn.
Wickes Boiler Co., Saginaw, Mich

Heating, District Steam

American District Steam Co., Lockport, N. Y.

Heating and Ventilating Apparatus

Green Fuel Economizer Co., Matteawan, N. Y.
Ohio Blower Co., Cleveland, O.
Sturtevant Co., B. F., Hyde Park, Mass.
Webster & Co., Warren, Camden, N. J.

Hoists, Electric

Yale & Towne Mfg. Co., New York.

Hoists, Hand

Yale & Towne Mfg. Co., New York.

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Peerless Rubber Mfg. Co., New York.
Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.

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Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.

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American Steam Gauge and Valve Mfg. Co., Boston, Mass.
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Indicators, Hydraulic

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Indicators, Speed

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.
Starrett Co., L. S., Athol, Mass.

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Crosby Steam Gage & Valve Co., Boston, Mass.
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Trill Indicator Co., Corry, Pa.

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Lunkenheimer Co., Cincinnati, O.
Ohio Injector Co., Wadsworth, O.
Penberthy Injector Co., Detroit, Mich.
Randle Mach. Co., Cincinnati, O.
Schutte & Koerting Co., Philadelphia, Pa

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Watson-Stillman Co., New York.

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Bristol Co., Waterbury, Conn.

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Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

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Lunkenheimer Co., Cincinnati, O.
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Philadelphia Lubricator & Mfg. Co., Philadelphia, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.
See Oiling Systems.

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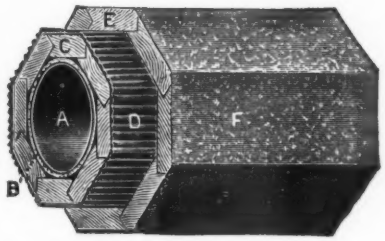

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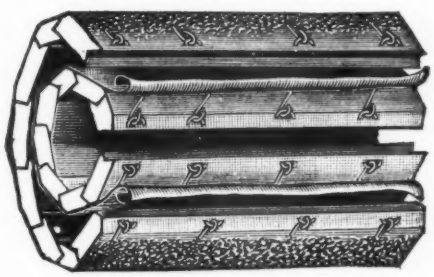

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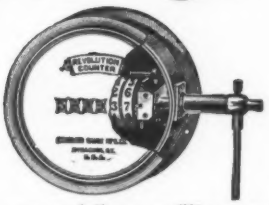

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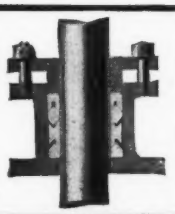

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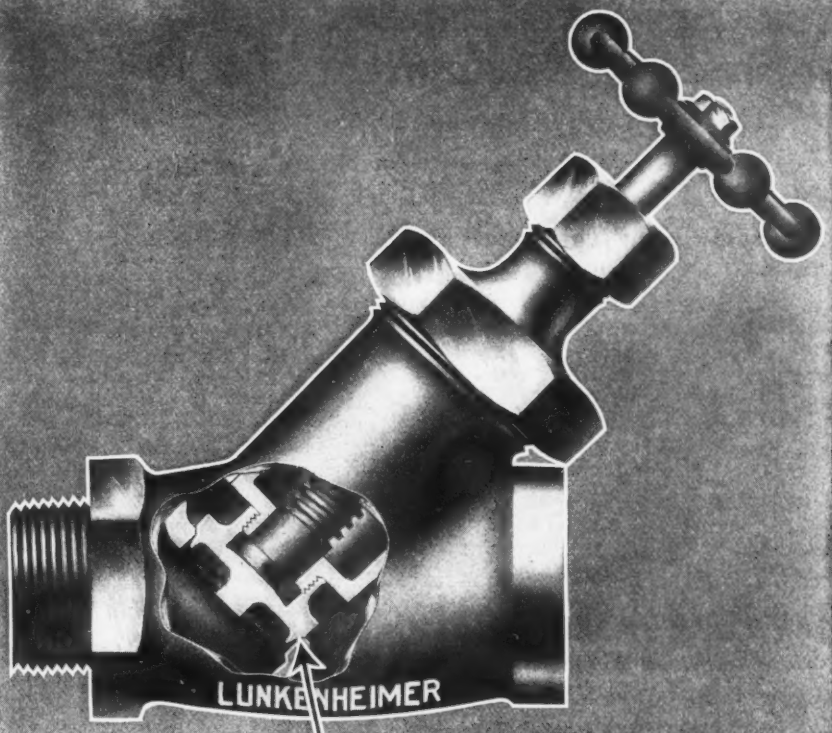

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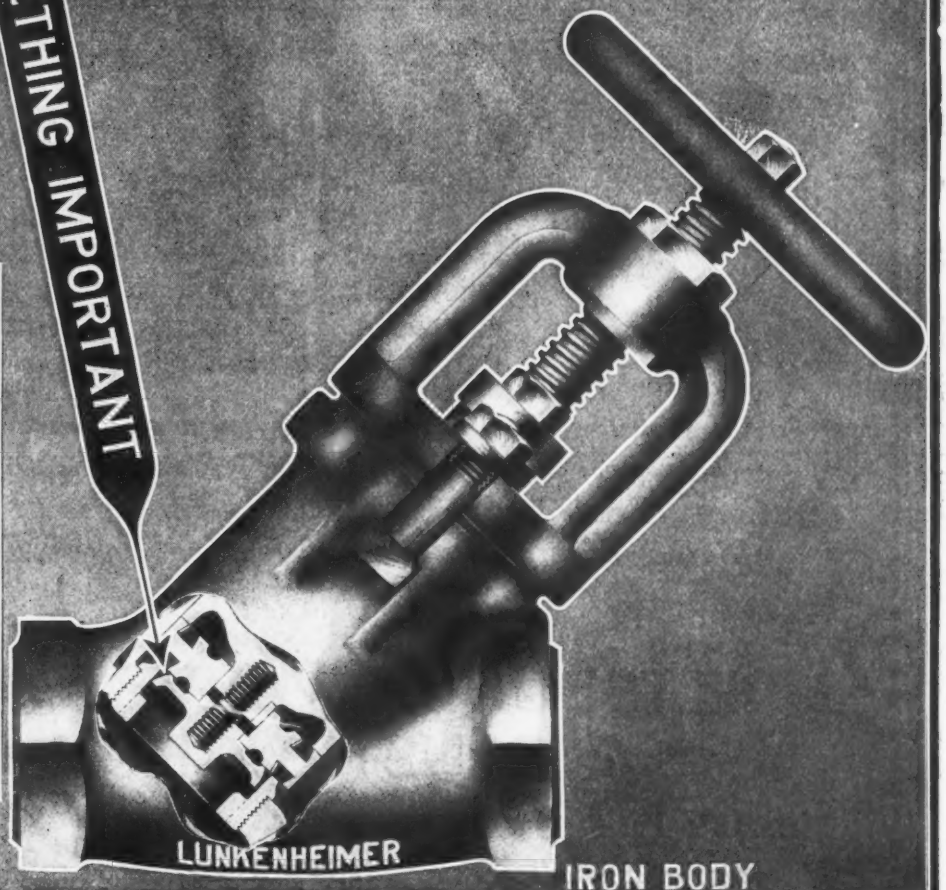

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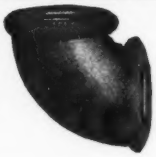

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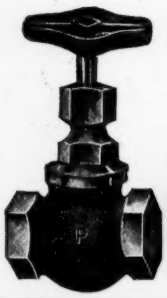

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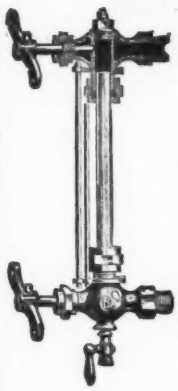

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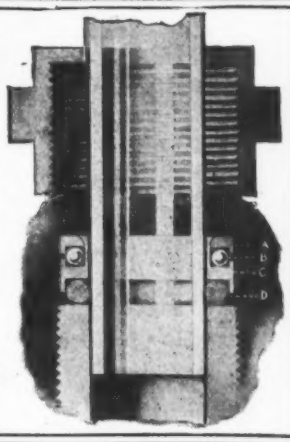

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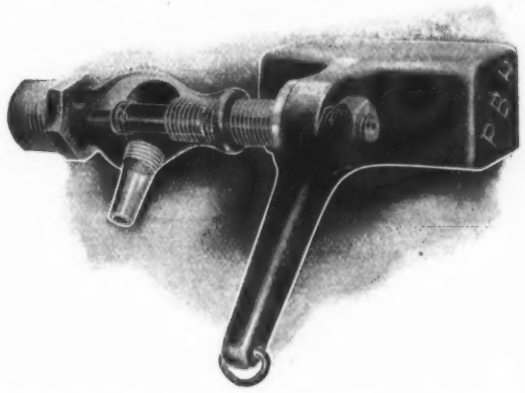

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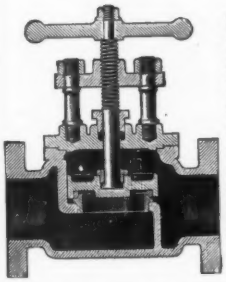

have the seat on the outside of an inverted cone where the direct current of steam does not come in contact with it, preventing all chance of wire drawing. Other features in catalog.

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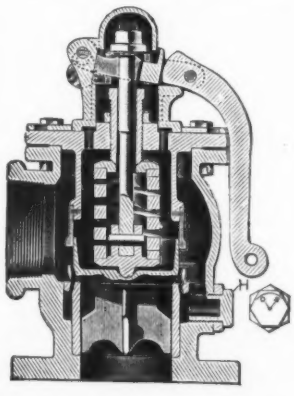

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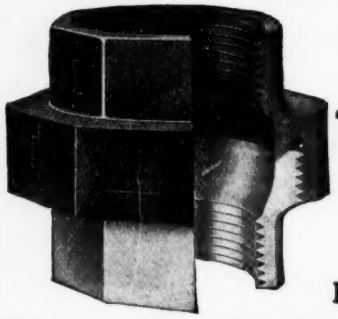

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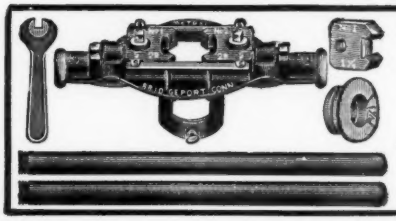

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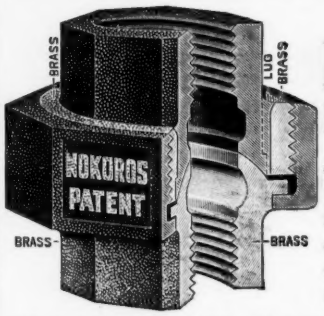

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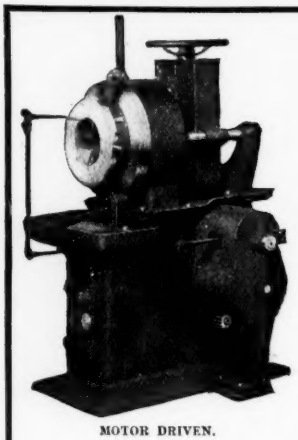

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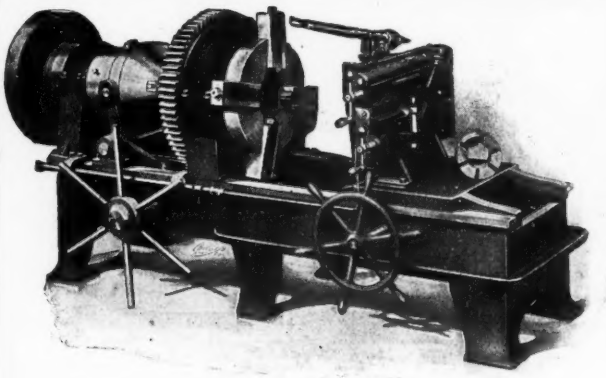

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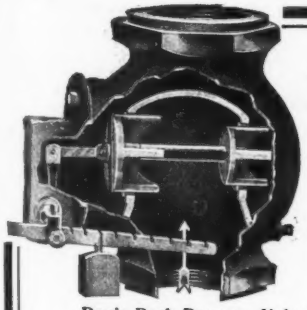

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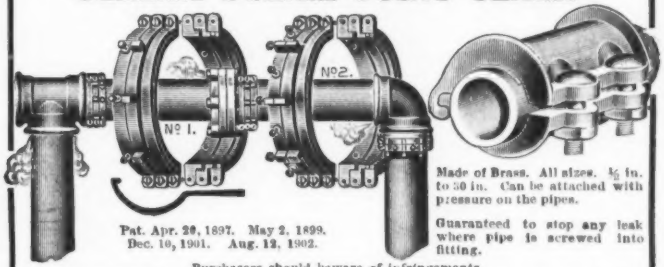

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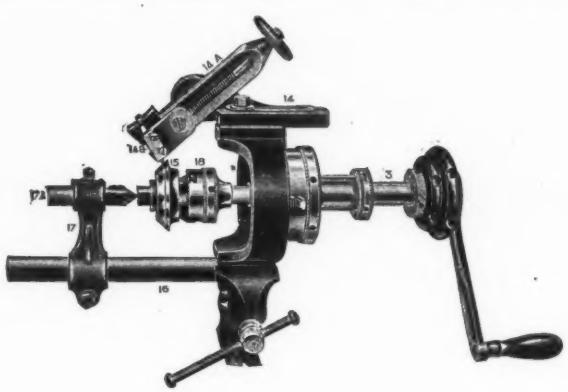

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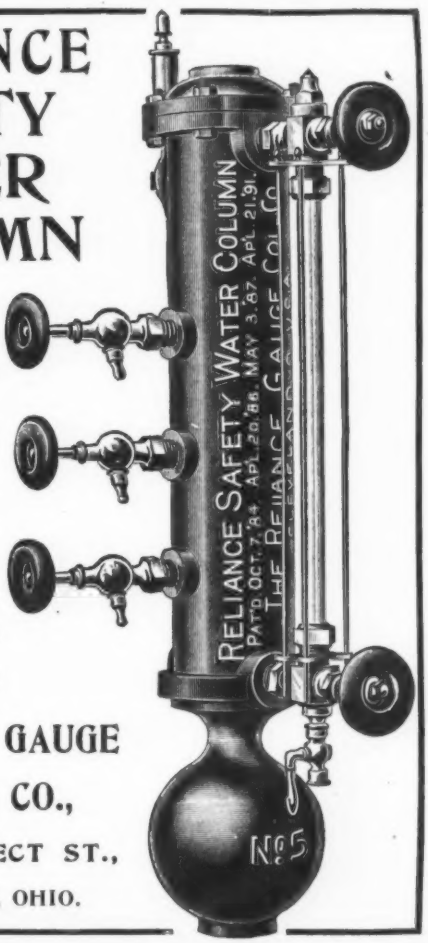

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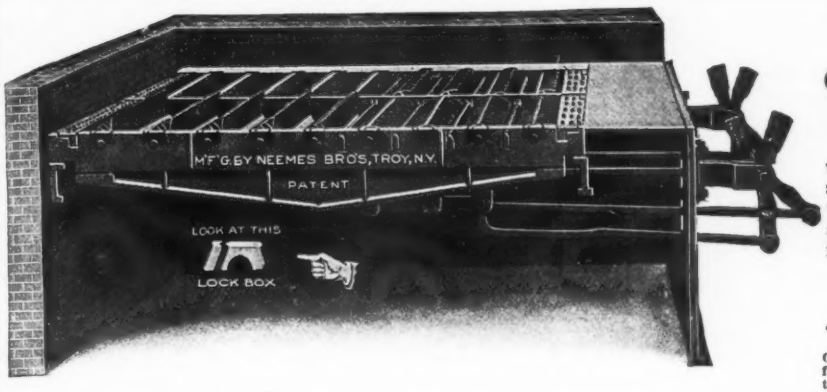

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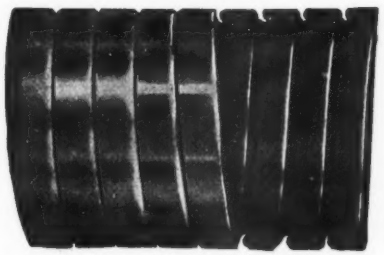

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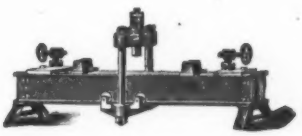

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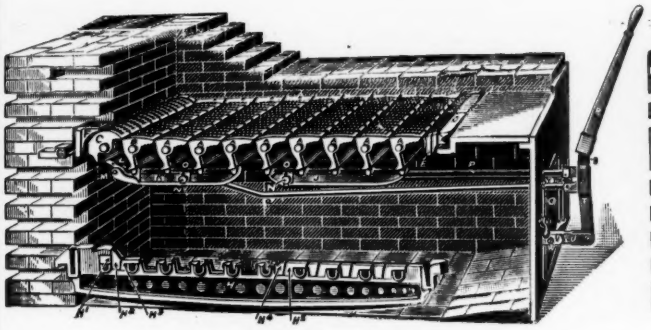
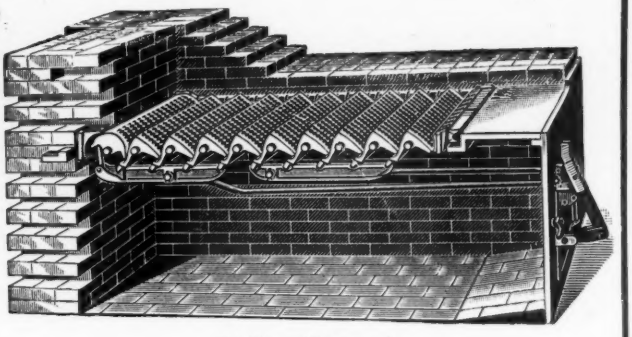
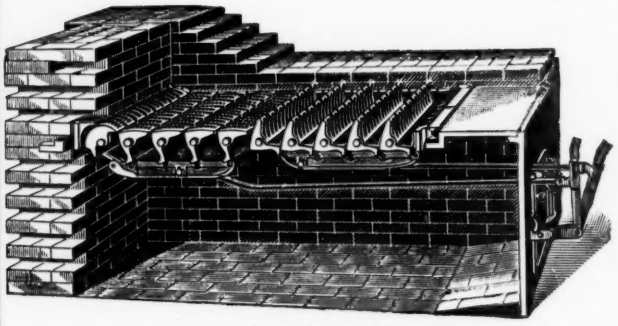


Normal Position of Grate

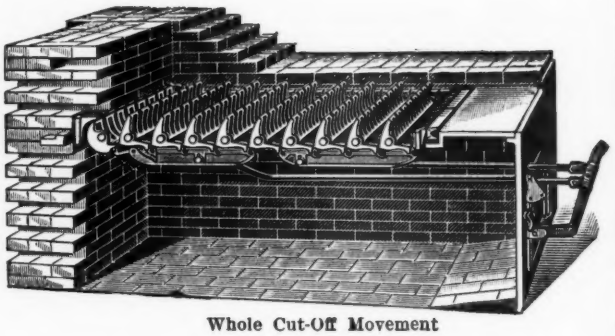


Shaking Movement

Argand Steam Blower



Divided Cut-Off



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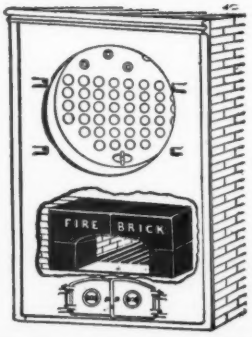
C-O-Two Furnace Co., Syracuse, N. Y.

Your Boiler Settings



require the protection of perfect fire brick Write for prices.

Presbrey Fire Brick Works
Taunton, Mass.

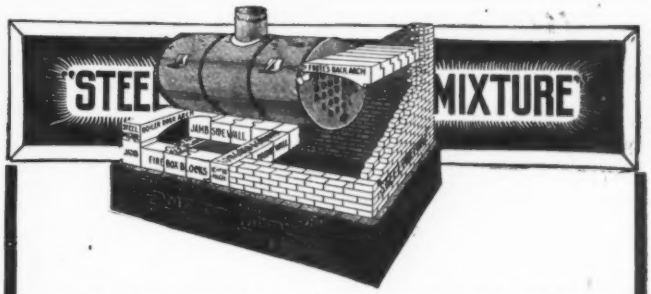
A DARK CLOUD

of smoke hanging over your plant is a positive indication that for every $100 worth of coal burned, from $5 to $15 worth goes up your chimney as waste fuel.

The Wilkinson Automatic Stoker and Smoke Preventer turns this dead loss into live profit. Let us tell you **how** in detail.

The Wilkinson Manufacturing Co.,
BRIDGEPORT, MONTGOMERY COUNTY, PA.

GREEN CHAIN GRATE STOKERS
AUTOMATIC SELF-CLEANING SMOKELESS
GREEN ENGINEERING CO.
COMMERCIAL NATIONAL BANK BLDG., CHICAGO
GENERAL FOUNDRY WORK A SPECIALTY



Over 7500 Hammel Oil Burners
In use under Stationary Boilers, Locomotives, Kilns, Etc.
Write for Circular of Hammel Patent Furnace for Water-Tube Boilers
HAMMEL OIL BURNER CO.
609 North Main Street. LOS ANGELES, CAL.

ONE REASON WHY

there is plenty of satisfaction to be obtained in the use of our Boiler Door Arch. The whole inner surface of the Arch contains just three joints. This means that destructive hot gases and more than destructive fire tools get little purchase on it.

With bricks the clay can become loosened and fall out. Then the heat can play on two or more sides of the brick, the fire tools can catch in the corners, and the breaking down process is helped along rapidly.

The comparatively jointless surface of our Arch does away with these conditions and the expensive repairs that go with them.

Send for a "Dimension Booklet."

McLeod & Henry Co., Troy, N. Y.
Branch Office, 1402 Broadway, New York City.

CARL VON HARTZFELT, M. C.,
Denatured Alcohol from Natural Gas.
Plans, specifications, estimates and supervision for
Continuous Industrial Alcohol Distillery Apparatus,
for light, heat and power purposes from natural gas and Portable Stills for vegetable waste matter. Economy and rapidity of construction a specialty. Unquestionable references.

ACTING DIRECTOR OF
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WHEELING, W. VA., U. S. A.
See Harper's Weekly, Oct. 3, 1908. Patent Serial No. 450,294—Aug. 25

ROGERS STYLE SHAKING GRATE

SALAMANDER GRATES

Twenty different styles, all made of same grade of iron---the best for the purpose. On the market for 55 years. Tried and true.

SALAMANDER GRATE BAR CO.
126 Liberty Street, New York

ROGERS STATIONARY GRATE

COMMON PLAIN GRATE—DOUBLE

The Monarch Boiler Arch hangs from above. It is a metallic backing faced with fire brick. Write for booklet.

MAYVILLE SPECIALTY MFG. COMPANY
MAYVILLE, WIS.

MARTIN GRATES

Martin Anti-Friction Rocking Grates will burn slack coal and get the same steam results as ordinary grates do with best lump coal. Catalog tells why.

MARTIN GRATE COMPANY, 281 Dearborn Street, CHICAGO.

Wing's Turbine Blower The *ideal* system of *forced draft.* Guarantees the best results from the cheapest fuels. Moderately priced. Write for catalog.

L. J. WING MFG. CO., 90 West St., cor. Cedar St., New York

SAGINAW MANUFACTURING CO.,
SAGINAW, MICH., U. S. A.
MANUFACTURERS OF
GILBERT WOOD SPLIT PULLEYS.
New York Branch, 88 Warren Street.
Chicago Branch, 32 South Canal Street.
Sales Agencies in all principal cities.
Cable Address, "Engrave" A. B. C. and Lieber's Code.

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WIEDERHOLDT CONSTRUCTION CO.
American Trust Bldg., Chicago, Ill.

Robins Laminated Leather Belting Is made continuous without laps, plies or cement. Guarantees an equal distribution of strength and an uninterrupted line of power transmission. Write for circular No. 2.

ROBINS NEW CONVEYOR COMPANY
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"SIROCCO" TRADE MARK
FANS AND BLOWERS
BUILT ON THE TURBINE PRINCIPLE.
SIROCCO ENGINEERING CO., 138 Cedar Street, NEW YORK.
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Pittsburg Office—1415 Keenan Bldg., F. K. Potter, Mgr.

RHOADS LEATHER BELTING

IT EXCELS IN SERVICE.

J. E. Rhoads & Sons
PHILADELPHIA 12 N. THIRD ST. — BOSTON — NEW YORK 40 FULTON ST.
HAMBLET & HAYES CO. EASTERN AGENTS, 105-111 SUMMER ST.
FACTORY, WILMINGTON, DEL.

ANY TYPE OF BOILER

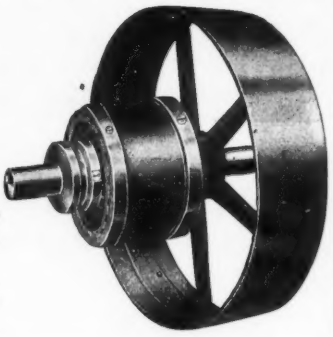
The Murphy Automatic Smokeless Furnace

burns slack and other low cost fuels with unexcelled economy and absolute smokelessness. Strictly automatic in feeding and distribution of coal and the removal of the ash. Send for a complete description.

MURPHY IRON WORKS, 5 Walker St., DETROIT, MICH.
UNITS OF ANY SIZE

The Akron Friction Clutch

is dust-proof, noiseless, reliable and works in an oil bath. Easily installed, adjusted and operated. Circular on request.



The Williams Foundry & Machine Co.,
Akron, - Ohio.
Successors to the Akron Clutch Co.

PREVENT SMOKE

Write to us for descriptive matter relating to a device that is mechanically correct, simple in construction, absolutely automatic, and its effectiveness in preventing smoke from Bituminous coal under any and all conditions has been fully demonstrated.

CLIMAX SMOKE PREVENTER COMPANY
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Belting Logic—If best Leather Belting costs per sq. ft. $1.00, best Rubber Belting 60c., and best Stitched Canvas Belting 40c., and with Leather showing 25% and Rubber 50% of the strength of **Best Stitched Canvas Belting,** wouldn't it be good policy for you as a practical man to investigate the merits of our product? Send for Book "C."

SAWYER BELTING COMPANY, CLEVELAND, OHIO.

The Boiling Test For "Duxbak" Steam-Proof Belting.

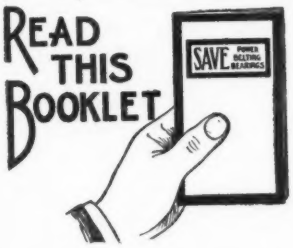
DUXBAK BELTING
TRADE MARK

After boiling one of these belts even an expert examination will not show the least sign of damage either to leather or cement. Sent on approval. Ask for the "BELT BOOK."

Chas. A. Schieren Company
ESTABLISHED 1868

Tanners, Belt Manufacturers. 69 Cliff St., New York.

Chicago, 84-86-88 Franklin St. Pittsburg, 240 Third Ave. Boston, 186-188 Lincoln St. Denver, 1622 Wazee St. Philadelphia, 226 North Third St. Brooklyn, N. Y., 13th St. and 3rd Ave. Hamburg, Germany, Auf dem Sande 1. OAK LEATHER TANNERIES, Bristol, Tenn.



It explains why
SHULTZ SABLE AND Aqua Water Proof Rawhide Belting
are so much better than ordinary belting. It further backs up our claims to superiority with opinions of representative manufacturers and power plant engineers about Shultz belts which have been in use from 10 to 25 years. Write for the booklet, or better yet, tell us your requirements and get a trial belt for 60 days' free use. If you don't like its performance you can send the belt back.

SHULTZ BELTING CO., ST. LOUIS, MO.
NEW YORK BOSTON PHILADELPHIA 34a

DON'T LET $4.80

Stand between you and healthy, long-lived, dependable belts.

Ask your dealer for a box of STEPHENSON Bar Belt Dressing, and see how quickly and gratefully your belts will respond to good treatment.

The results will delight your heart and your check book.

Be sure our registered Trade-Mark, The man with the Cog-Wheel Face, is on each Pound Stick.

Don't confuse the Brands:

RED Label Brand for Leather Belts
GREEN Label for Rubber and Canvas

$4.80 for a 12-lb. box

Of Dealers Everywhere, or

STEPHENSON MFG. CO.
ALBANY, N. Y.

THERE'S NO LETTING GO WHEN OXOILOX GETS BUSY.

BUT IT'S THE BELT THAT DOES THE GRIPPING

If a belt has been thoroughly treated with **OXoilOX** you can't make it slip. Run it at full load and full speed—it clings to the pulleys like a chain to the sprocket. **OXoilOX** gives new strength to **old tired belts.** It drives out the "sticky stuff" with which they are usually saturated; makes them clean, pliable and tough. They do **more work** and do it **better.** For **new belts** the best possible start in life is a treatment with **OXoilOX.** It takes the stiffness out; restores the vitality lost in tanning, and helps them get right down to work. Whether old or new, a belt treated with **OXoilOX** adheres so closely to the pulleys that air is absolutely excluded and it's the vacuum thus formed that enables it to **run slack** at **full load without slipping.** Write for sample.

F. S. WALTON CO., Philadelphia.
Gentlemen:—Kindly send us free of all charge, a sample can of OXoilOX, the perfect belt dressing.

Name..... Name of Firm.....

Address..... Number of Belts.....Average Size.....

F. S. WALTON CO., Philadelphia, Pa.

Pressers and Refiners of all grades of Neatsfoot Oil.

SPECIFY

Latest **Improved**

ROCHESTER
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Automatic **Lubricators**

when ordering your NEXT engine.

SOLE MANUFACTURERS

GREENE, TWEED & CO.

109 Duane Street, **NEW YORK.**

The First Aid to Lubrication-

"TACOMA"

of Engine or Machinery bearings should be a first-class Oil Cup. It should be of substantial construction—easy to regulate—should maintain a predetermined and constant rate of feed without waste, and without any liability of the feed adjustment becoming disarranged by jarring or vibration.

Williams Oil Cups

meet these demands perfectly. They are compact, finely finished and are made by experts who "know how" because they have had experience in this line covering a period of more than a score of years. Williams Oil Cups are made in great variety sufficient to meet every lubricating need.

Consult us on lubrication matters. One of these devices may save you considerable annoyance and enable you to forget many lubricating ills.

Write for Williams Oil Cup Booklet.

THE D. T. WILLIAMS VALVE CO.

904-910 BROADWAY - CINCINNATI, OHIO

6

THE LARGEST PLANT ON EARTH ADOPTS THE *WHITE STAR OIL FILTER*

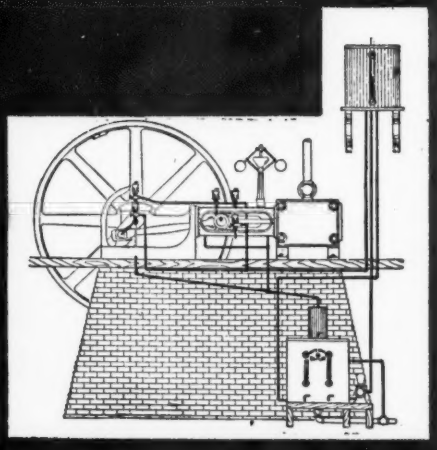
The Engineering Profession knows that the GARY, INDIANA, plant of the Indiana Steel Company, the largest commercial power installation ever undertaken, has been designed as to every detail of equipment by expert engineers. The selection of the "White Star" emphasizes the already widely accepted fact that highest efficiency is insured by its use.

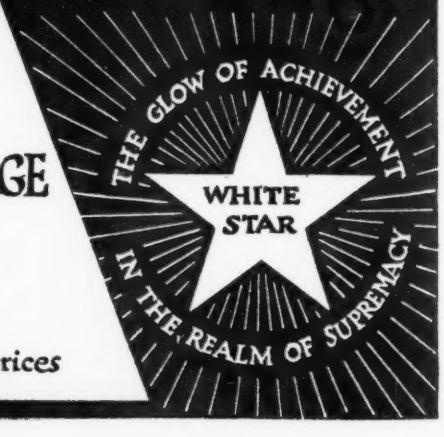
Manufactured by

THE PITTSBURGH GAGE & SUPPLY CO.,

PITTSBURGH, PA.

Write for Catalogue and prices





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Your Bearings And Cylinders With

DIXON'S Flake Graphite

It imparts to rubbing surfaces a wonderful smoothness that relieves oil or grease of a very considerable portion of its task of keeping the microscopically rough surfaces apart, and thereby reduces the wear and heat of friction to the lowest possible point. In the bearing Dixon's Flake Graphite renders cutting and seizing impossible.

In the cylinder it prevents cutting and scoring, assures smooth valve motion and uniform steam distribution.

Write us for a free sample can No. 94 C, and try "Dixon's" in your plant.

Joseph Dixon Crucible Company,

JERSEY CITY, NEW JERSEY.

"Hard Lines"

The Trudge for Work.

He's certainly to be pitied—the *untrained* man without a job. Just one of the hopeless, struggling crowd.

Every *good* position—requiring special knowledge—is closed against him.

And there's always a line of *others* "waiting to see the foreman" or rushing to answer the advertisement, for the poorest bread-and-butter job.

Just your two hands and your shop experience wouldn't carry *you* far—if slack times should come.

Let your dread for the future stimulate you to do something *now* to improve your chances. Set your mind on the better position you want—and win it.

Don't waste your time "thinking it over"—don't build air castles, just buckle down and do it.

Why not make the start today that will keep you forever out of the hand-to-mouth class? Put in part of the long Winter evenings at home, fitting yourself for a better *kind* of work, and bigger pay.

We can help you. There's always a big demand for men *trained* in engineering work—Steam, Electrical, Mechanical, Civil or Architectural. Get a thorough technical training that will fit you to hold one of these well paid positions—through our simple, practical courses of Home Study. And without loss of time in your present work.

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Ask for our advice and the proof of what we have done for 80,000 others. Mark and send coupon—today. We'll send you a valuable book FREE describing our complete courses.

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....Mechanical Engineer	....Telegrapher
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....Municipal Engineer	....College Preparatory Course
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Name.....

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Occupation.....

Power, 12-29-08

COSTS LESS

ALBANY GREASE

LUBRICATING COMPOUND. TRADE MARK.

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PATENTED JULY 28 1868

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THE PERFECT LUBRICANT

WORKS BEST

Send for free ALBANY GREASE CUP and liberal samples of ALBANY GREASE

ADAM COOK'S SONS, NEW YORK

Detroit Improved Standard Lubricator

Some One

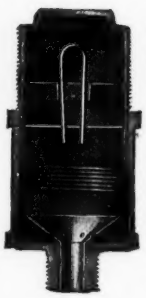
of our 337 different styles and sizes of sight-feed lubricators will fill any requirement you may have.

When ordering, insist on getting the genuine Detroit.

Write for a catalog of the most complete line of oiling devices for all purposes.

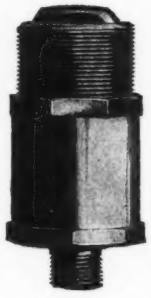
DETROIT LUBRICATOR COMPANY.
Detroit, U. S. A.

The "Philadelphia" Grease Cup



Automatic application of grease to the bearing without the use of spring compression. : : : :

Nature Supplies the Feeding Force in the Form of Compressed Air. : : : : : :



With many thousands of the "Philadelphia" Grease Cups in successful operation, on machinery of almost every description, we offer a system of lubrication which, for simplicity, cleanliness, economy, reliability and efficiency has no equal.

The "Philadelphia" Cup is not merely "as good as any other:" IT IS THE BEST, and we are prepared to prove our claim for actual superiority. There are more reasons for its practical success than we have room to mention here.

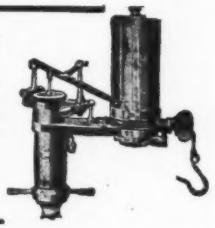
Write for catalogue and full information

The Philadelphia Lubricator & Manufacturing Co.
The Bourse (Exhibition Dept.), Philadelphia, Pa.

? Indicates a Good Indicator ?

Features like these. An outside spring, steam jacketed cylinder, etc., absolute accuracy, etc. You'll find them in the Trill Triumph Indicator for superheated steam, gas engines and high pressures. Catalog.

TRILL INDICATOR COMPANY,
Eagle Street, CORRY, PA.



Graphitize Your Oil

with Graphlio—The Crystalline Graphite. By so doing, you double the efficiency of the oil and save at least 45% in the amount of oil used. Write for Circulars.

WALTER D. CARPENTER & CO.,
39 CORTLANDT STREET, NEW YORK.

HARRIS

TRADE MARK—REG. U.S.PAT. OFF.

OILS

For Steam Engine Lubrication

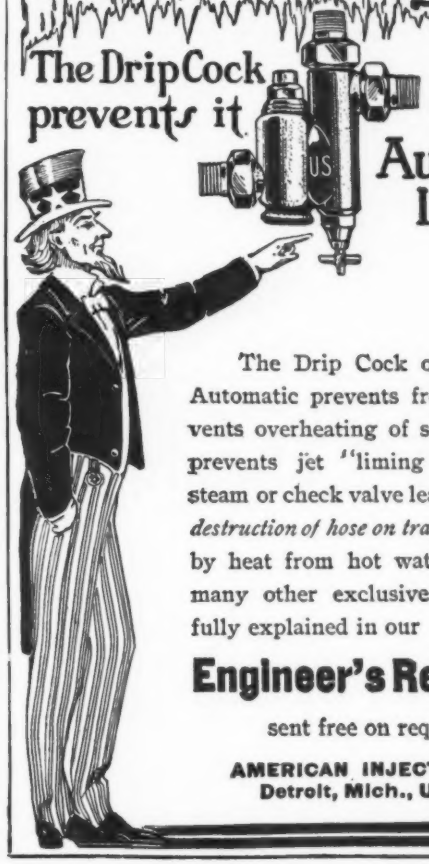
Special grades for the High Pressure and Low Pressure Cylinders, also SUPERHEATED STEAM. Our catalog points out the distinctive merits of these oils. Shall we send you one?

A. W. HARRIS OIL CO.
323 So. Water St., Providence, R. I.

No Freezing Here

The Drip Cock prevents it

U.S. Automatic Injector



The Drip Cock of the U. S. Automatic prevents freezing; prevents overheating of suction pipe; prevents jet "liming up" when steam or check valve leaks; *prevents destruction of hose on traction engines* by heat from hot water, and has many other exclusive advantages fully explained in our

Engineer's Red Book

sent free on request.

AMERICAN INJECTOR CO.
Detroit, Mich., U. S. A.

Chicago Automatic Injectors

Prove their Quality in Actual Operation

Chicago Automatic Injector

No boiler feeding troubles when you have a powerful Injector that is built for service.

The Chicago Guarantees a Full Boiler when you want it

It is positive in its work and has nothing to get out of order. Built unusually strong.

THE BEST PROTECTION FOR BOTH BOILER AND ENGINEER

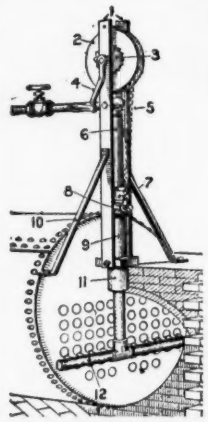
You cannot afford to be without it. It makes the power plant complete.

THE CHICAGO EJECTOR, a powerful little instrument for elevating, forcing and conveying liquids. Does marvelous work with but little steam.

Write for description and catalog of both the Chicago Injector and Ejector.

THE OHIO INJECTOR COMPANY,
The World's Greatest Injector Manufacturers.
WADSWORTH 110 Main Street OHIO, U. S. A.

Chicago Ejector



"Flues Shine Like Gun Barrels"

is the statement of a Milwaukee engineer who uses the "Henry" flue cleaner. Operates while the boiler is in commission. Cleans with the draft. Direct and positive action on each flue.

Write for descriptive matter. Agents wanted.

The Henry Steam Flue Cleaner Co.,
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AWAY WITH SCALE

Put Pyramid Boiler Compound in your feed water and you'll never have troubles in your boiler. WE WILL GUARANTEE THAT. Write.

Some territory still open for agents of the $5,000 class.

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THE HAWK-EYE BOILER COMPOUND NEVER FAILED.

See our Advertisement in First Issue Every Month.

HAWK-EYE COMPOUND CO.,
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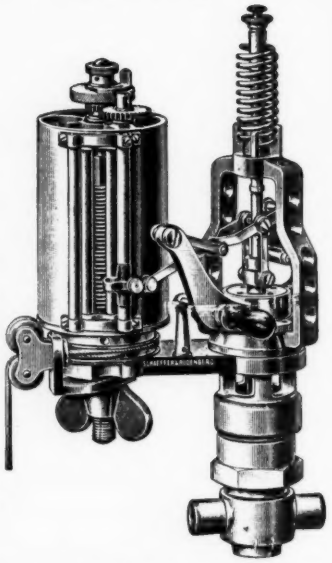
The S. & B. Thompson

IMPROVED CONTINUOUS CARD INDICATOR

The Most Modern, Useful and Practical Indicator on the Market.



This indicator shows not only the condition at a specified moment, but for a time sufficiently long to determine the true condition by the average showing. For engines in traction powerstations and rolling mills, or wherever the load constantly varies, the continuous card diagram is of utmost value, and you will appreciate it when you know that from 50 to 100 indications can be taken without removal of the paper. Write for new catalog.

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Main Office and Works, 963-5 Kent Avenue, Brooklyn, N. Y.
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BIRD-ARCHER BOILER COMPOUNDS

are the best scale preventatives for Ice Plants, Distilleries, Breweries, Large Hotels, Bakeries, or any industry where live steam is used in processing. They never taint the steam to discolor or in any way contaminate the product.

You can't buy better boiler protection. We are so sure of this that we take the responsibility. If a six months' trial doesn't convince you that our compounds remove old and prevent new scale effectively and without injuring boiler fittings, packing or cylinder lubricants, you don't have to pay one cent for the compounds.

Tell us your conditions and get our book: "Boiler Troubles and Their Prevention."

Bird-Archer Company
90 West Street 17 **New York**

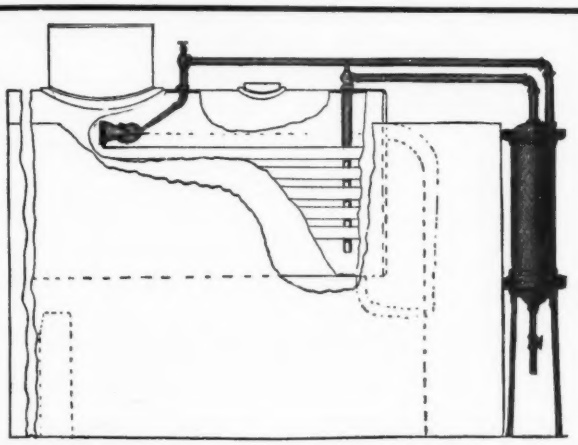
Don't Let Scale Form

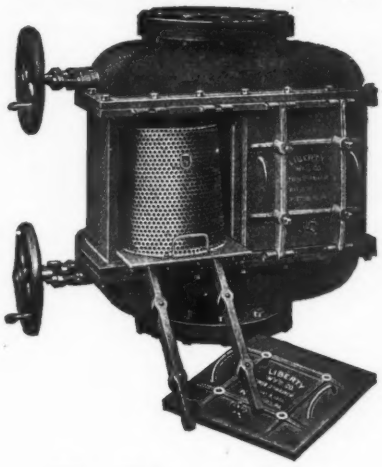
then you won't need boiler compounds or mechanical scale removers.

The Buckeye Automatic Skimmer

floats just at the water level and draws off the impurities which always rise to the surface. Try one for 30 days, free.

Buckeye Boiler Skimmer Company,
South End, Toledo, Ohio.





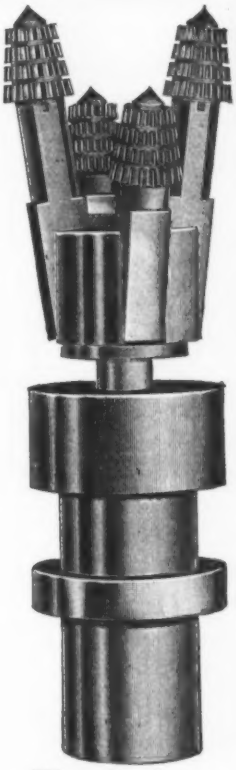
The Twin Strainers

Liberty Power Plant Accessories

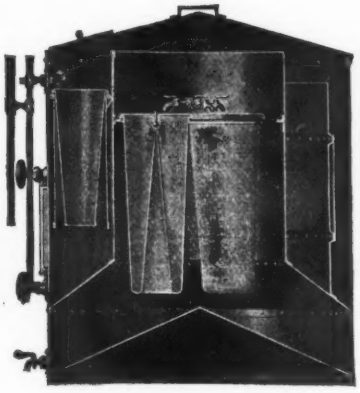
are WELL designed
WELL built and
Do their work WELL

WELL! WELL!! WELL!!!

Why Not INVESTIGATE?



The Cyclone Cleaner Air or Steam

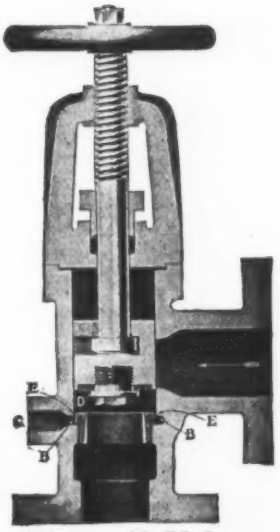


Oil Purifiers

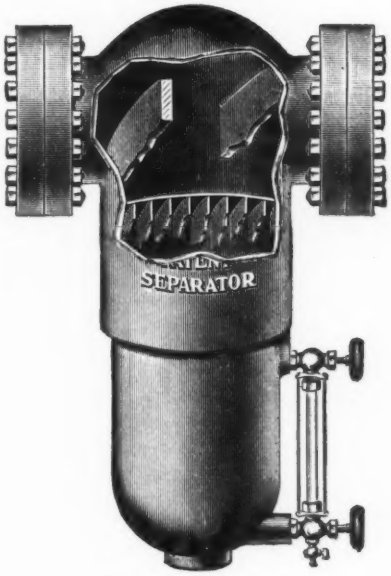
Investigation will result in your using them in *your* power plant.

Liberty Appliances

are *approved*, RECOMMENDED and USED by the most up-to-date Engineers in this and foreign countries. WHY? The answer will be found in our *catalogue—for the asking.*



Blow-off Valves



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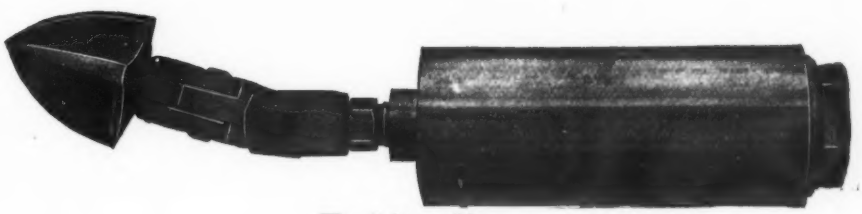

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FOR VERTICAL BOILERS.

You can't expect any old cleaner with spindling arms and measly cutters to do much to the scale unless you give it all kinds of time, and have unlimited patience. Hurry a flimsy turbine, and you will find only spiral grooves on the surface of the scale. The one and only turbine for cleaning vertical or any other tubes, is the

WEINLAND WING HEAD TURBINE CLEANER

You can see from the picture that the cutters work in three planes at once, and as the machine moves down the tube the surface is cleaned three times before the head passes.

In addition to doing the work in three stages, the work accomplished in any stage is better than with a light and flimsy head because the extra heavy Wing Arms of the Weinland are forced hard into the scale by centrifugal force.

Get a Weinland Wing Head Cleaner on trial. If water is scarce, or if you have compressed air, ask about the rotary air cleaner instead of the turbine. The trial is free. If the cleaner doesn't make good send it back.

For heavy scale the WEINLAND MECHANICAL CLEANER driven by electric, air, or steam motor is the only practical machine, and if you don't shut down long, if scale accumulates quickly, or if you have many boilers, this cleaner saves its cost in no time.

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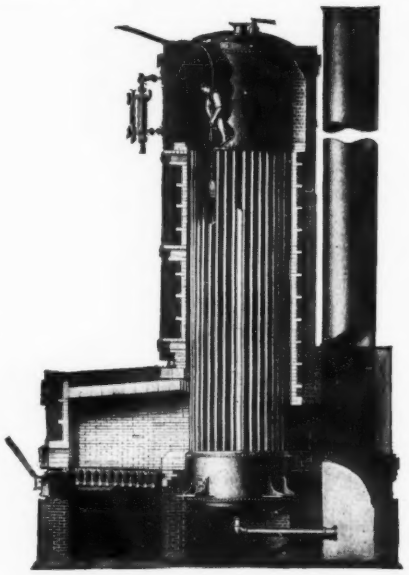

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At work in straight vertical tubes.

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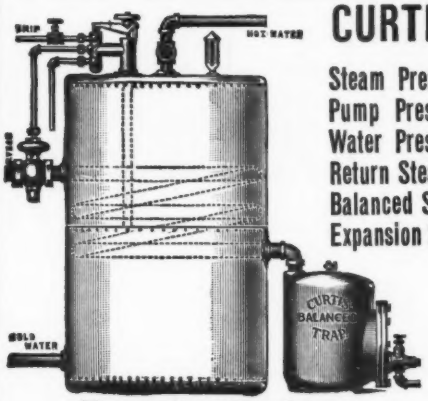

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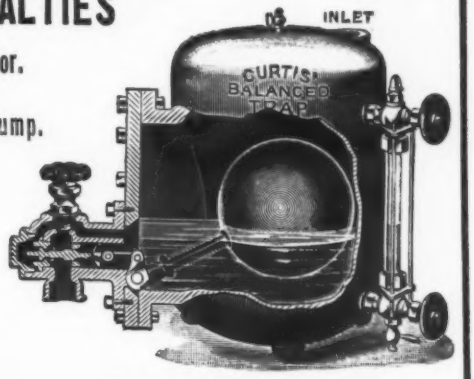

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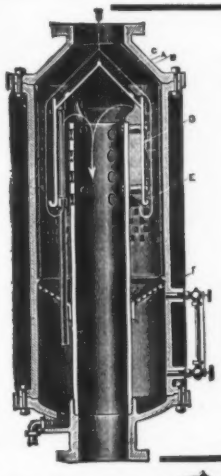

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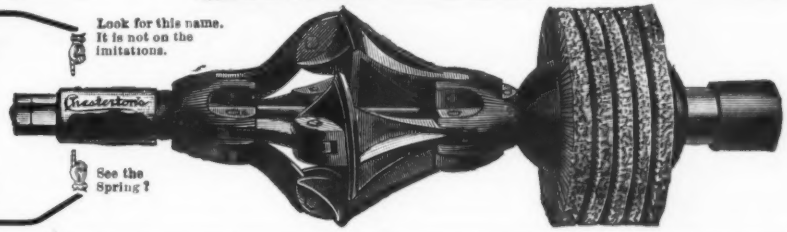

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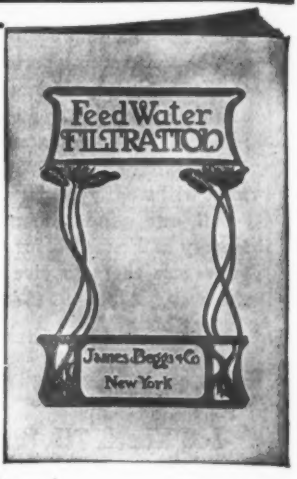

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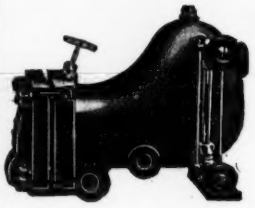

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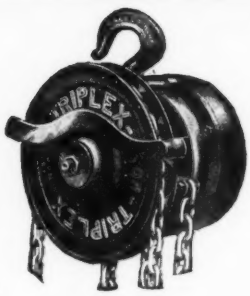

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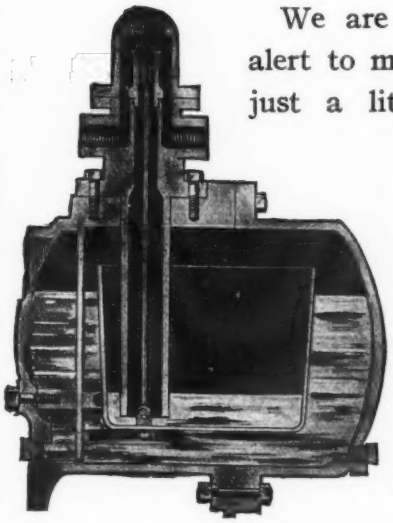

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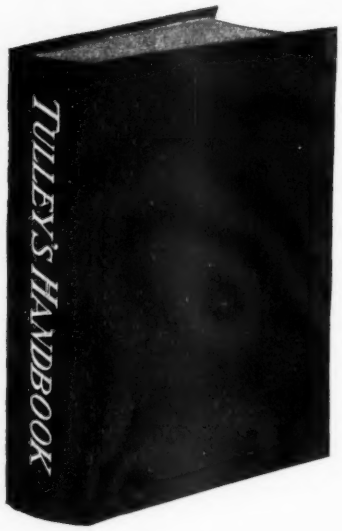

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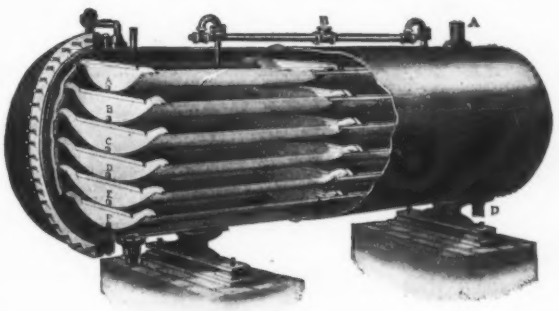
In Hoppes Live Steam Feed-Water Purifiers *no use is made of chemicals*, but the same principle is employed as in the Exhaust Steam Feed-Water Heater. The raw water is brought into *direct contact* with the live steam on the large heating and lime-catching surface of the pans. Its temperature is raised to almost that of steam in the boiler, and as in the Exhaust Steam Heater, the scale-making solids are precipitated and retained on the pans, but the purification is much more complete owing to the high temperature of the live steam. *No expense after installation* except for cleaning which is merely nominal. Write for particulars, prices and guarantee.



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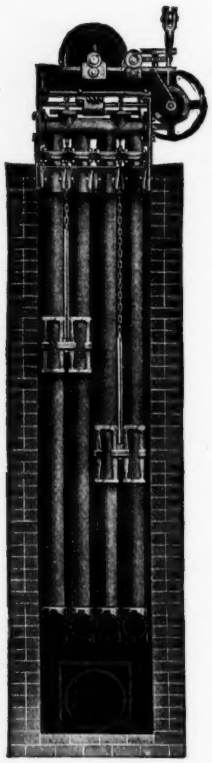
ECONOMIZERS
In Small Steam Plants



The price of fuel and the rate of boiler driving largely determine the profit on an economizer. In small boiler plants both are apt to be high. Expensive fuel, such as anthracite or coke is often used, especially in cities, and as the call for steam outgrows the original plant, the boiler is forced harder and harder. The gases then pass to the chimney at a high temperature and the heat thus carried away is as good as so much lost money.

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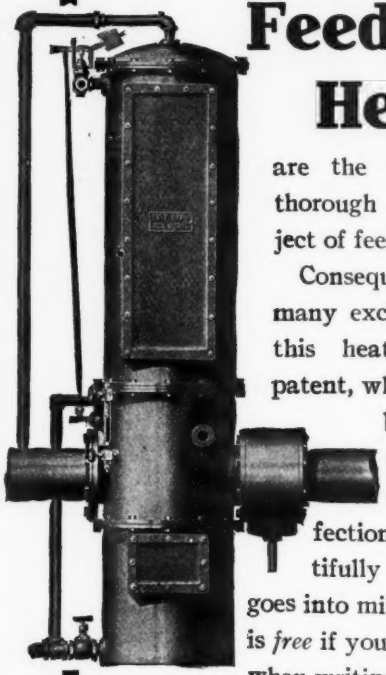
Erie City Open Feed Water Heaters



are the result of a most thorough study of the subject of feed water heating.

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SIMPLE—they contain just two parts, the helical tube and the outer shell.

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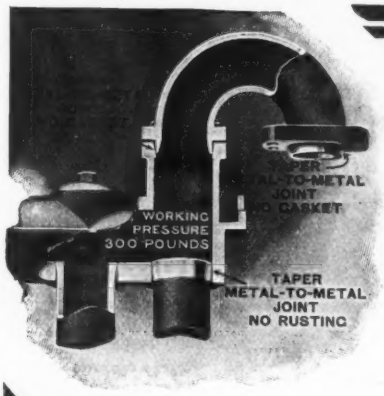

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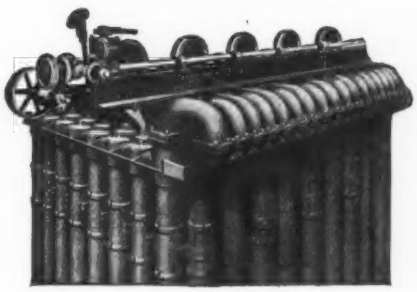

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is GUARANTEED by us to heat the feed water to the boiling point, using the exhaust steam only. All the impurities in the feed water that will precipitate at that temperature are retained in the Heater. All the oil is extracted from the exhaust. All tubes expand and contract independent of the others.

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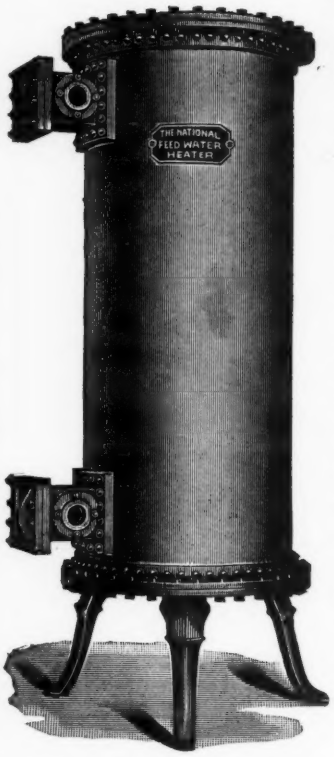

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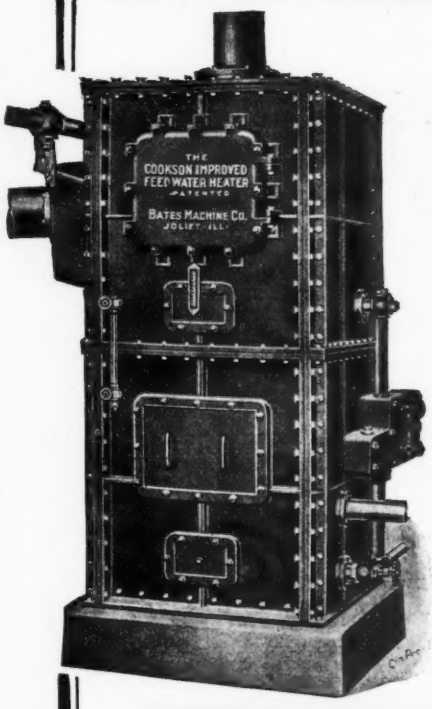

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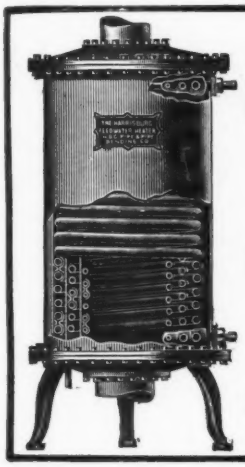

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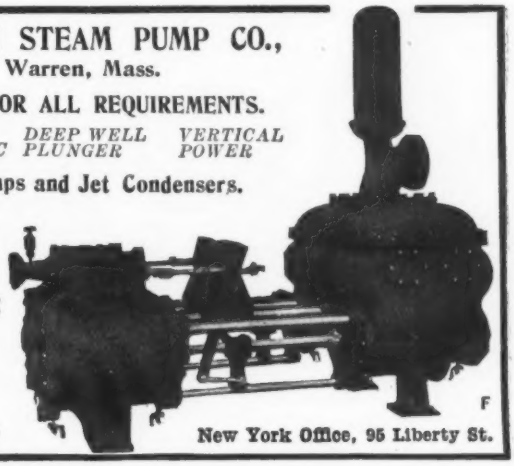

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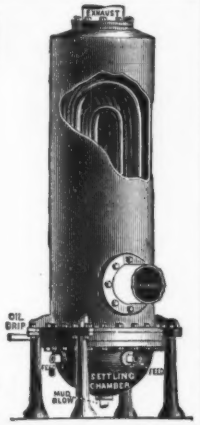

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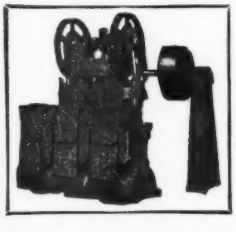

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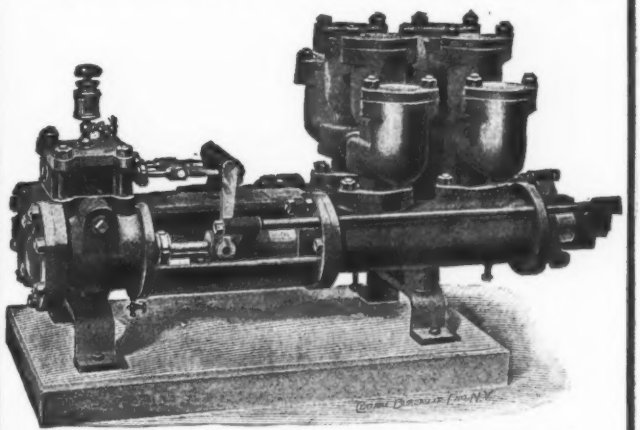

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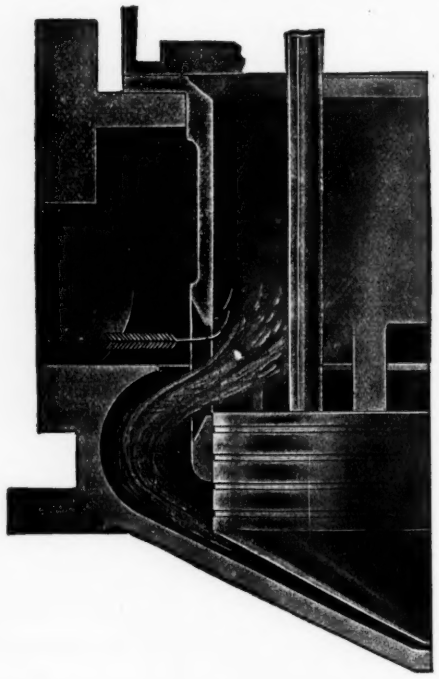

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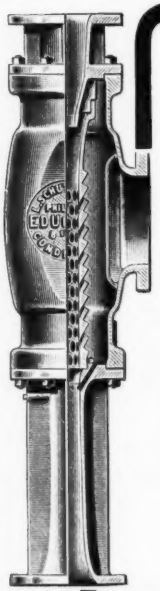

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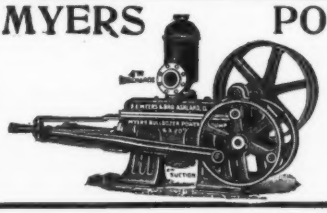

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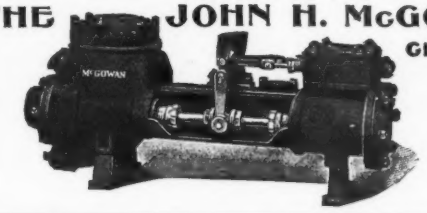

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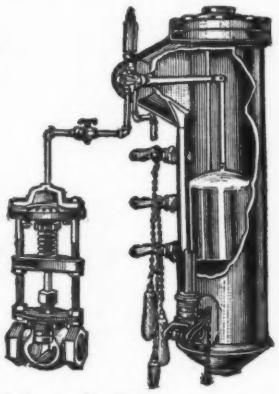

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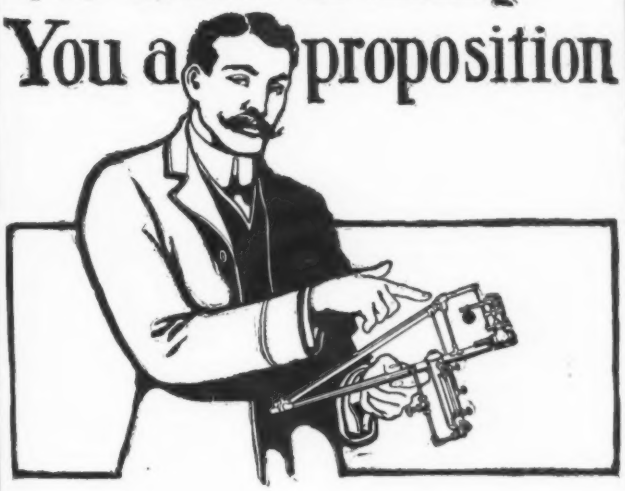

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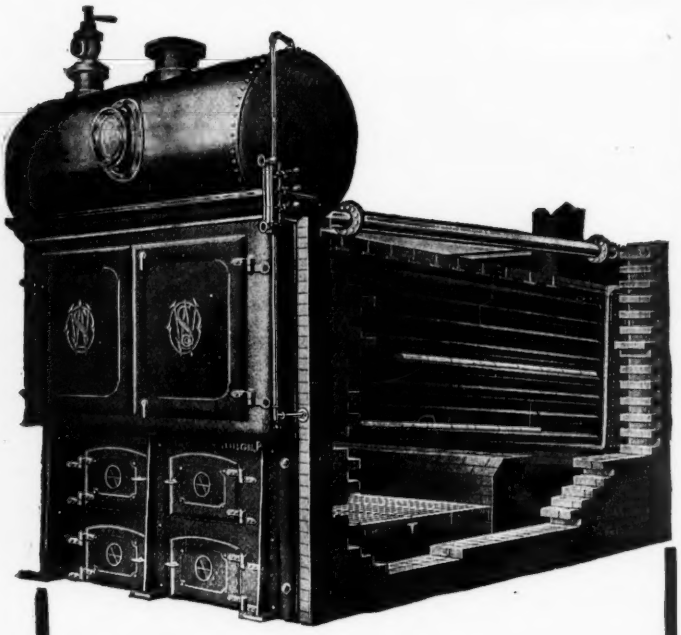

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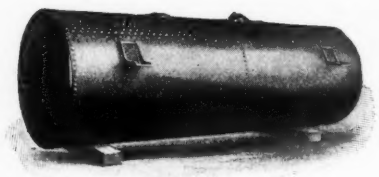

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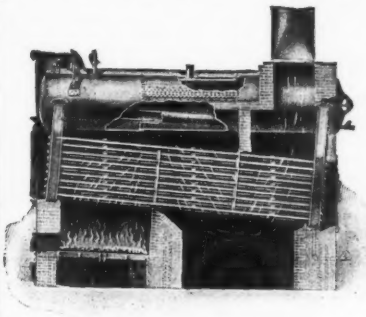

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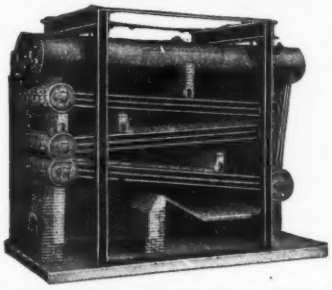

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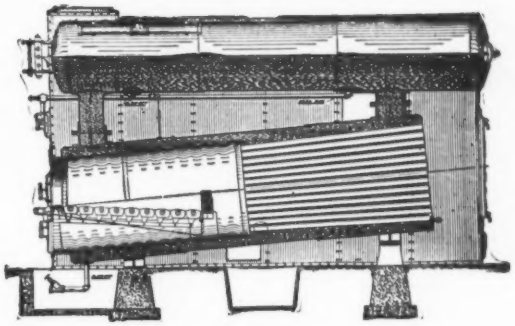

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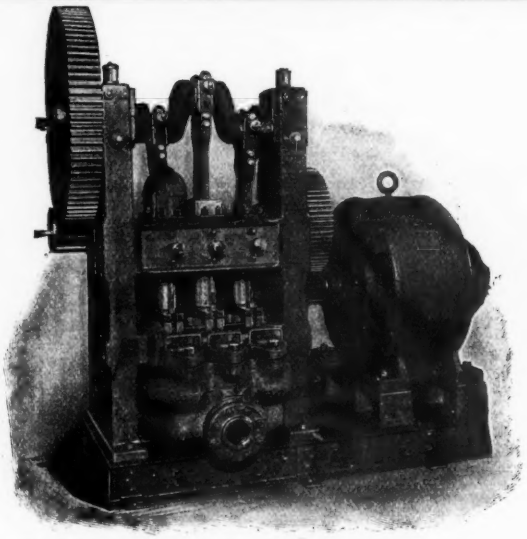

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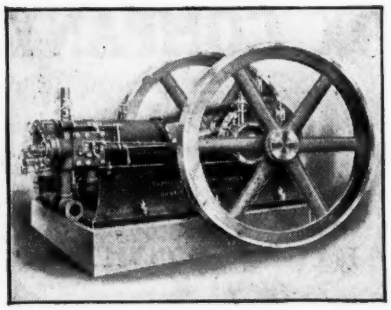

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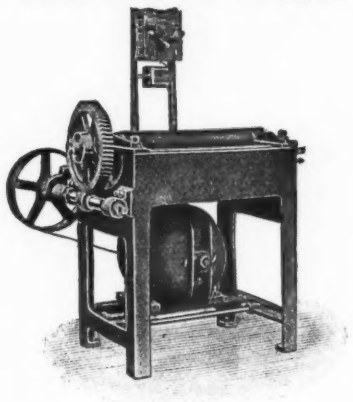

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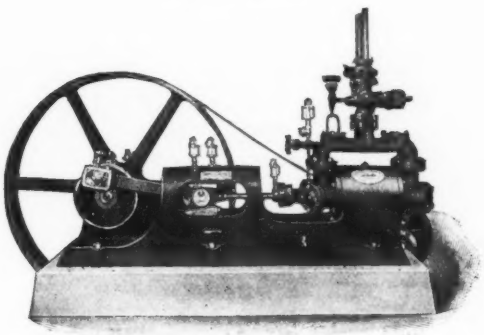

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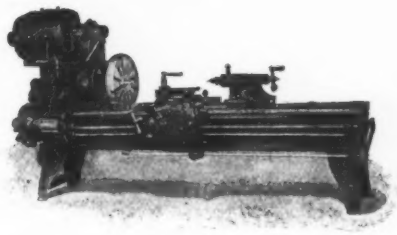

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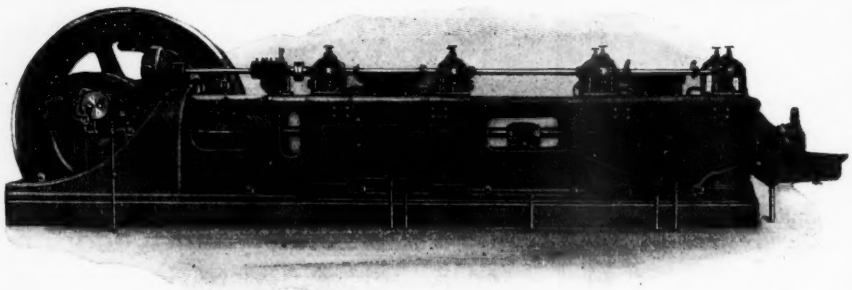

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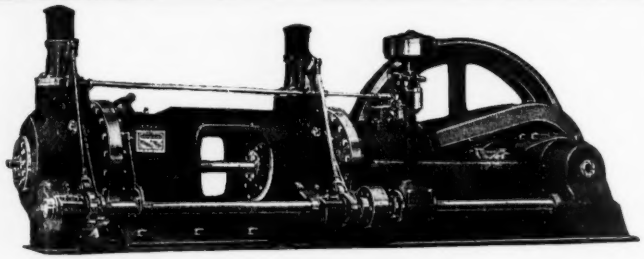

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FEW IN NUMBER
EASY OF ACCESS

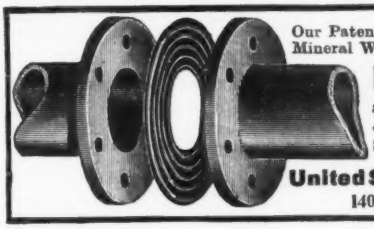
ENGINES OF VERTICAL AND HORIZONTAL TYPES
75,000 HORSE POWER IN SUCCESSFUL OPERATION

STRUTHERS-WELLS COMPANY, - - - Warren, Penna.

SOUTHWARK FOUNDRY

AND MACHINE CO., PHILADELPHIA, PA .

PORTER-ALLEN AND CORLISS STEAM ENGINES **WEISS CONDENSERS**
BLOWING ENGINES FOR BLAST FURNACES **PUMPING MACHINERY**



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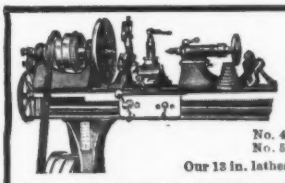

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LATHES
W.F. AND J.C.
8 in. to 13 in. Swing.
No. 4½ Lathe, 9 in. x 25 in., List $ 75.00
No. 5 Lathe, 11 in. x 34 in., List 100 00
Our 13 in. lathes made 5 to 10 feet long. Send for lathe catalog.
W. F. & JOHN BARNES CO., 990 Ruby Street, Rockford, Ill.

Lammert & Mann

Engineers and Machinists

157 S. Jefferson Street, CHICAGO

WE MAKE A SPECIALTY OF

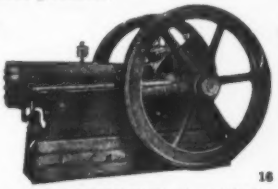
Corliss Engine Repairs. Engines Indicated.
General Jobbing. Repairing Engines.
Pumps, etc., all kinds Special Machinery.
Pulleys, Hangers, Shafting, etc. Oil Dash Pots.

FOOS
GAS AND GASOLINE ENGINES

HAVE WIPE SPARK IGNITER, positive acting and self cleaning.

VERTICAL VALVES, mechanically operated, admit fuel charge into cylinder at atmospheric pressure.

CENTERLINE COUNTERBALANCING increases the efficiency and decreases the fuel bills.

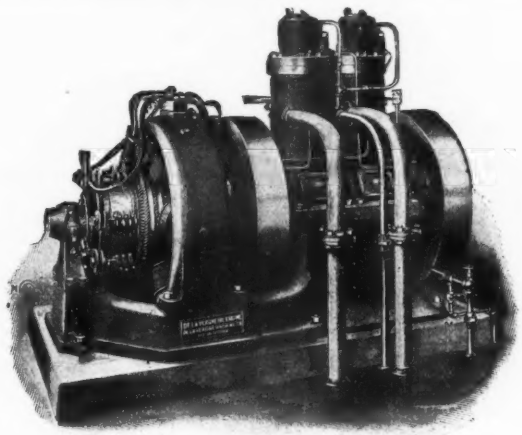


ACCESSIBLE DESIGN makes it a simple matter to keep Foos Engines properly adjusted.

Get Catalogue No. 26.

16

THE FOOS GAS ENGINE CO., SPRINGFIELD, OHIO.



For small and medium sized plants our

OIL ENGINES

are cheaper, simpler. more compact than any other motive power. 8 H. P. hours per gallon of cheap oil.

5315 H.P. used by Baldwin Locomotive Works

The "De La Vergne" Vertical two-Cycle 4 to 25 H. P.
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DE LA VERGNE MACHINE CO.

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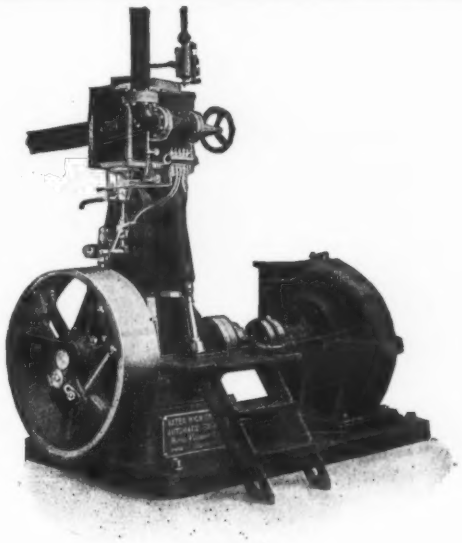


Bates Vertical Automatic High Speed Engine for connection to Pumps. Especially adapted for

WATER WORKS, IRRIGATION

and other places where it is desired to move a large volume of water at small expense.

CATALOG FOR THE ASKING.

BATES MACHINE CO., Joliet, Ill.

The Engine For Hotels, Office Buildings And Hospitals.

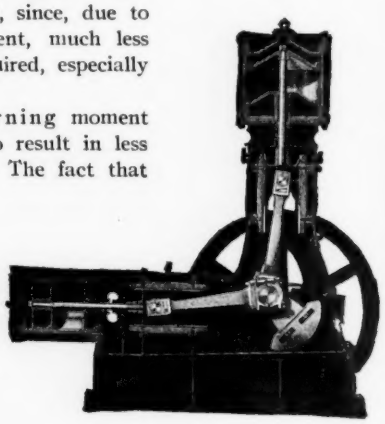
SUPPOSE a giant were to bounce a two- or three-ton rubber ball up and down in the basement of your building at a rate of 250 times a minute. Would you notice any vibration on the upper floors? A similar thing occurs when you install, say, a single-cylinder 160-H.P. electric-light engine and run it at the same speed.

The best that can be done to balance a single-cylinder engine is but a poor compromise. With no counterweight there is a powerful tendency to shift the engine to and fro upon the foundations. If the reciprocating parts are completely balanced, equal unbalanced forces are created in a vertical direction that have an effect upon the engine foundations similar to that produced by the bounding of the two-ton rubber ball. The engine designer usually takes the middle course—that is, puts on a counterweight about half heavy enough to counterbalance the reciprocating parts, so that instead of a two-ton rubber ball you have a one-ton ball.

We offer you an engine that has no unbalanced forces whatever, that can in fact be set upon a light foundation, such as second-story concrete floors, without bolting down, and can then be run at full speed without producing the least tremor.

Such an engine is the **American-Ball Angle Compound,** which has two cylinders set at right-angles so that the resultant of the forces produced by the reciprocating parts can be exactly balanced in all positions by a single counterbalance. This arrangement results furthermore in a marked saving of room. There is likewise a saving in weight, since, due to the even turning moment, much less flywheel capacity is required, especially or driving alternators.

The more even turning moment and lighter flywheel also result in less wear on the bearings. The fact that the engine is compounded reduces the steam consumption by 25 per cent. as compared with a single-cylinder engine.



Before finishing the plans of your engine room get Bulletin No. 14

The American Engine Co.

22 Raritan Ave., Bound Brook, N. J.

Ballwood Engines

are slightly higher in cost, but this is *more than justified* by their wonderful economy, efficiency and durability. No other "prime movers" possess Ballwood Quality. We build

Single Valve

Center Crank, Automatic Cut-off Engines, single cyinder and compound;

Corliss Valve

Non-releasing Gear Engines, both vertical and horizontal—simple and compound.

Also Welded Flanged Pipe And Bends

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THE BALL & WOOD COMPANY,

ELIZABETHPORT, N. J.

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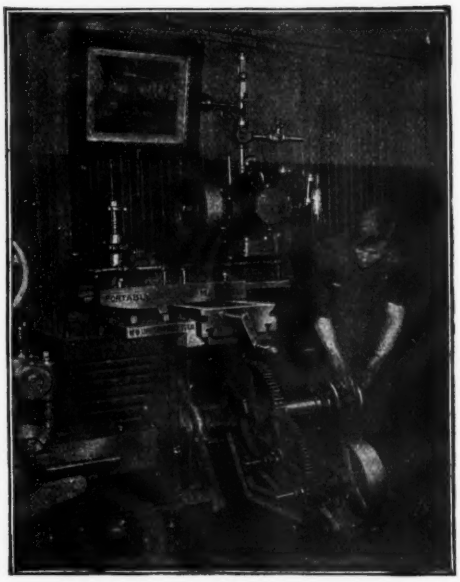

Isn't This Better Than Dismantling The Engine?

We'll rebore any cylinder up to 120 in. right in position. That's not all! We make all kinds of quick repairs for all kinds of engines. You'll save money in the end by sending for us at the start. Our workmen are all experts, and skilled in the handling of our special portable tools. Repairs can generally be made overnight and the whistle can blow in the morning as usual. **AMMONIA CYLINDERS INDICATED.**

H. B. UNDERWOOD & CO.,

ESTABLISHED 1870.

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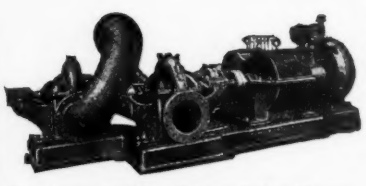

De Laval Turbine-Driven Series Pump.

Steam Turbine Motors
Steam Turbine Dynamos
Steam Turbine Blowers
Steam Turbine Centrifugal Pumps
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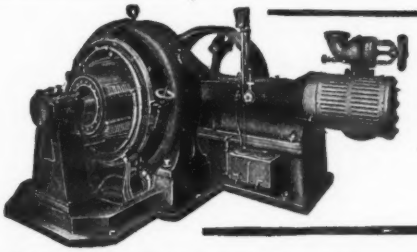

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THE STEAM TIGHT VALVE KIND

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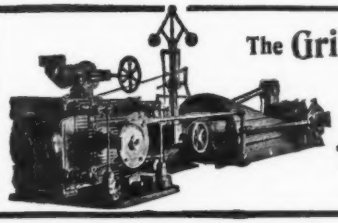
ANY SPEED FROM HIGH TO LOW—TRUMP ALWAYS

Northern motor drives insure a good play at all times—a handful of trump speeds for the operation of pumps, blowers, compressors, conveyors, etc. Means that each machine is driven at the speed best suited to its load for operating conditions. ¶Booklet 839 will suggest some means of applying Northern motors in your work to assure maximum results.

NORTHERN ELECTRICAL MANUFACTURING CO., Madison, Wis., U. S. A.
Manufacturers of Standard and Special Electrical Machinery. 872

RICE & SARGENT
CORLISS ENGINES
Reliable and Economical.
Designed and Built by
PROVIDENCE ENGINEERING WORKS,
Providence, Rhode Island.



The Griffith & Wedge Co.
Established 1840
Zanesville, Ohio, U. S. A.
Manufacturers of
The Ohio Corliss Engine
and Hoisting Engines

1865 **1908**
OLD RELIABLE
PHOENIX ENGINES and BOILERS
Meadville, Pa.

Are You Particular?

Do you like to *know* that everything is *right* and as it should be? You get that satisfaction with a

Shepherd Engine.

Then there's the economy of operation that comes with quality and workmanship. Altogether, they're a good proposition, and our catalog will interest you.

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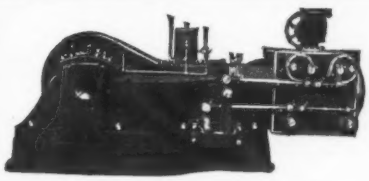

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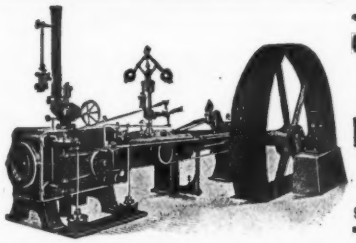

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Refrigerating and Ice Making Machinery
THE VILTER MFG. CO.
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Its consistent record of success and popularity is not accidental but the result of constant effort devoted exclusively to engine building for the past fifty years. Write for Bulletin No. 15.

THE ROLLINS ENGINE COMPANY,
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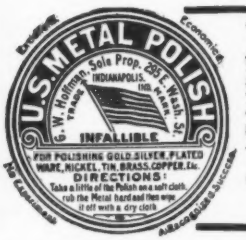
The Allan Metal
for Pistons and Bearings.
A. Allan & Son 482 Greenwich St. N.Y.



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that works quick and easy and keeps its lustre. Holds old trade and makes new. IT DOES NOT DETERIORATE. Established 16 years.

3-Ounce Box for 10 cts. 5-Pound Pails, $1.00

Sold by Agents and Dealers all over the world. Ask or write for Free samples. Highest Award, Chicago, '93; St. Louis, '04.

GEO. W. HOFFMAN, Expert Polish Maker,
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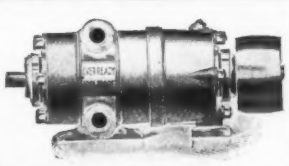
AN ECONOMICAL AND DURABLE ROTARY ENGINE
Send for Catalogue.
Ball-Cooley Engineering Co.
316 HUDSON ST., NEW YORK CITY and 159 GREEN ST., BOSTON.



A Different And Better Bearing Metal

Stays where it's put and is frictionless. It has a new efficiency for all factory and machinery bearings and its lasting power is remarkable. Sells for 25c a pound at all dealers, or direct from us in 50-lb. trial boxes. Try it.

Reeves Pulley Company,
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ALBERGER TANDEM GAS ENGINES
ACCURATE REGULATION FOR ELECTRIC SERVICE-AUTOMATIC CUT-OFF AND RITES FLY-WHEEL GOVERNOR
A.H. ALBERGER COMPANY
45 TO 600 H.P. USING NATURAL GAS
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695-697 ELLICOTT SQ.
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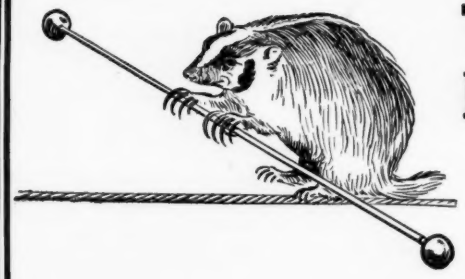

The Moving Parts of Wisconsin Engines are perfectly balanced

and besides this, every other valuable feature known is embodied. They are controlled by the Wisconsin Releasing Gear, the only real valve gear improvement in 20 years.

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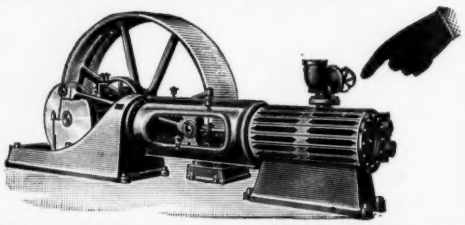
Fitchburg Engines Lead All Others

in close regulation of speed and steam economy. They are guaranteed steam tight for 25 years on one hour's work per year.



Catalog 61?

FITCHBURG STEAM ENGINE CO., - FITCHBURG, MASS.

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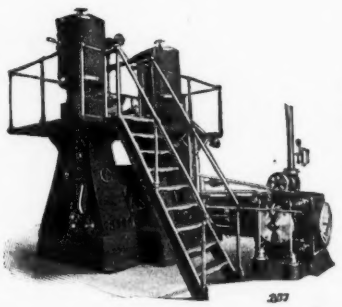
York, Pennsylvania



We manufacture all machinery and parts needed to equip a complete Ice or Refrigerating plant—

Machines, Condensers, Tanks, Cans, Coolers, Piping, Boilers and Ammonia Fittings

of all kinds. We employ over 1,250 men in the manufacture of Ice and Refrigerating Machinery exclusively. Catalogue sent upon request.

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BUILDERS OF HIGH CLASS

STEAM AND GAS ENGINES

HIGH IN DUTY, SUPERIOR IN REGULATION

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ABSOLUTELY RELIABLE

CORRESPOND WITH US BEFORE PURCHASING

CATALOGS ON APPLICATION

Fine Results From Cooper Corliss Engines

are being secured in all classes of service. We are Engine Builders and also do complete Steam Plant Engineering.

The C. & G. Cooper Co.
Mt. Vernon, Ohio.

Branch Offices:

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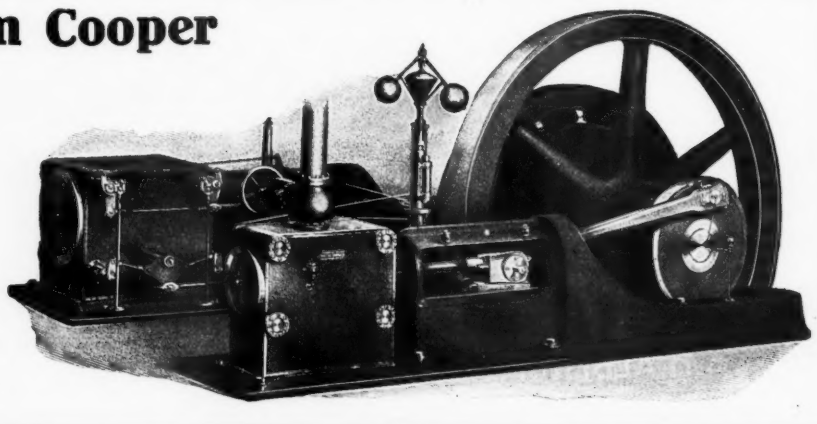

Robt. Wetherill & Co., Inc.

CHESTER, PENNSYLVANIA.

CORLISS STEAM ENGINES

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POWER PLANTS BOILERS

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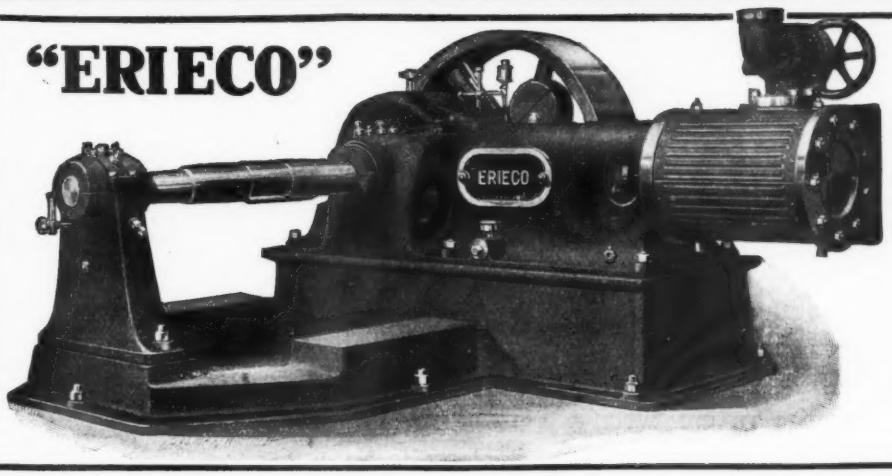

The Engine that lasts longer and gives more satisfaction per day than any other.

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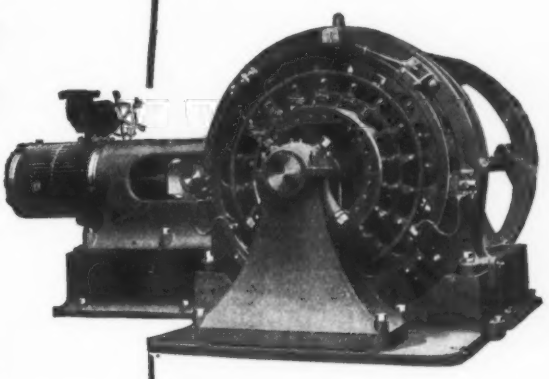
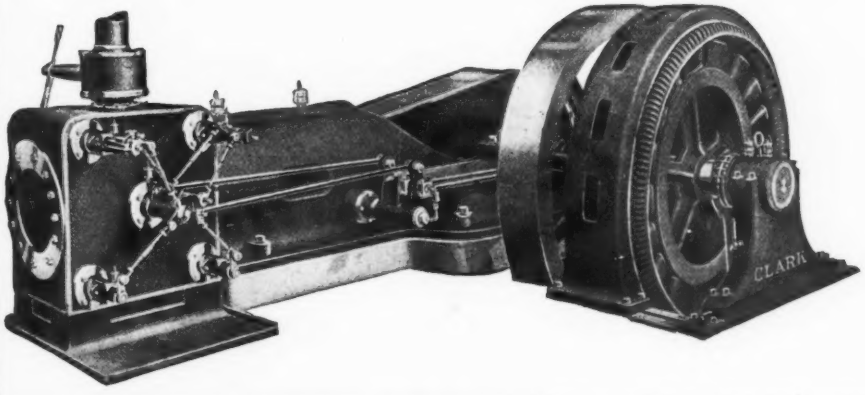
The Balancing Coils Of Ridgway Dynamos

neutralize and absolutely prevent all distorting effects usually caused by armature reaction. *Write for Bulletins.*



Ridgway Dynamo & Engine Co.

Works - Ridgway - Pa.



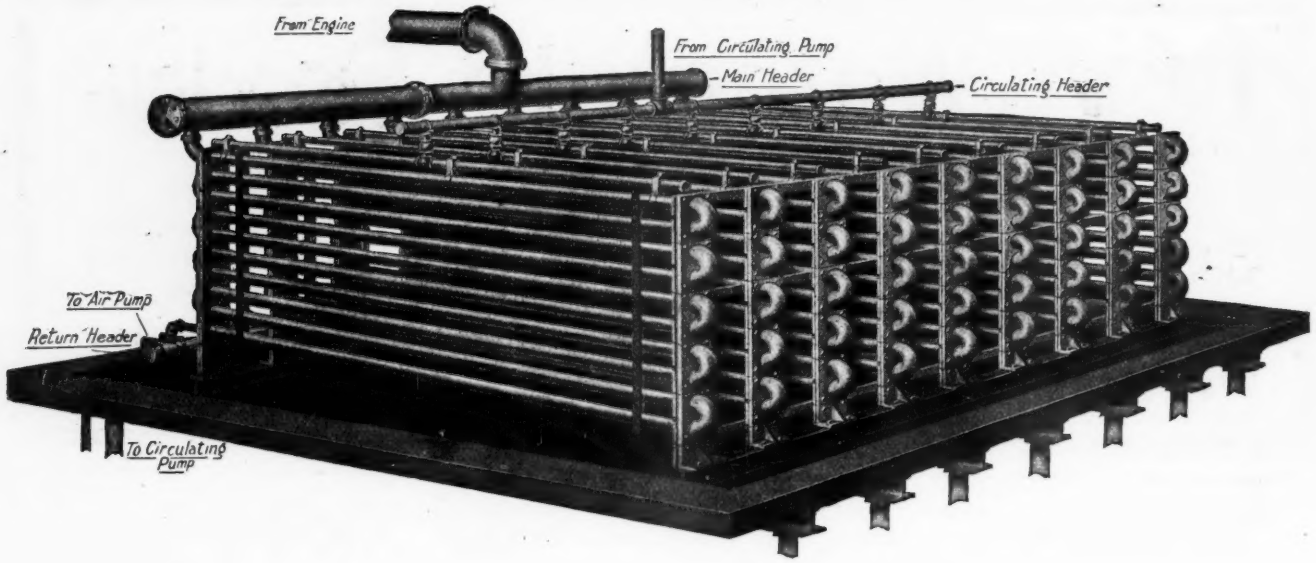
An Engine Without a Peer

Built simple, tandem and cross compound, and for speeds up to 200 R.P.M. Has ALL the advantages of the releasing gear Corliss, with none of its objectionable features or limitations.

The only Corliss engine ever designed having an unvarying valve travel, with perfect cut off at any point from zero to three quarters stroke. Engineers should investigate this engine. Catalogue free.

CLARK BROS. COMPANY

Belmont, N. Y.



EVAPORATIVE SURFACE CONDENSERS

This cut shows a condenser in daily service at our own Power Plant averaging 25-inch vacuum when taking the exhaust from engines of 1,000 H.P. capacity. It is placed out of doors where the air can circulate through the apertures freely, its efficiency being largely due to the water evaporated from the outside of the tubes. The same water is used over and over again, only a small amount of fresh water being added from time to time—the amount of circulating water required is very small.

This Evaporative Surface Condenser is suitable for use with all kinds of water but is *especially* adapted to the use of plants where available water is very bad—holding in solution a large percentage of scale-forming matter which would render a regular surface condenser useless in a short time or with jet type of condenser would be unfit for boiler use. The whole condenser is open to inspection at all times and is readily and easily cleaned.

We have installed several of these Evaporative Surface Condensers in Minnesota and the Dakotas where the water is very bad and they are doing splendid service. We shall show cuts of these from time to time in future issues of POWER AND THE ENGINEER and will be pleased to refer you to the users.

We would appreciate inquiries from you regarding these condensers, also in regard to Twin City Corliss Engines and Muenzel Gas Engines and suction producer plants.

MINNEAPOLIS STEEL AND MACHINERY CO MINNEAPOLIS

KEYSTONE GREASE

Will Rid You Of This Kind Of A Hold Up

If you have a yearly oil contract, now is the time to try Keystone Grease.

Then you'll be ready to make the change as soon as the contract will let you. There's no doubt about your **wanting** to change —once you have tried "Keystone" in the first place, because

Keystone Grease Lasts 50 Times As Long As Oil

It is the one and only perfect lubricant for all kinds of machinery where highest economy, cleanliness, safety and purity are considered important.

Keystone Grease contains no fat, acid, gums, rosin, talc or other injurious materials—has a natural body which it retains in heat and cold. There is no dripping, spattering or waste. Every particle of Keystone Grease is used up in actual lubrication, and the friction load is reduced almost to the point of annihilation.

KEYSTONE
TRADE MARK
REGISTERED U.S. PAT. OFF.

See our advertisement on page three.

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PHILADELPHIA, PA.

New England Office—10 Oliver Street, Boston, Mass.
Chicago Office—1210 Tacoma Building.
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Southern Office—610 Chartres Street, New Orleans, La.
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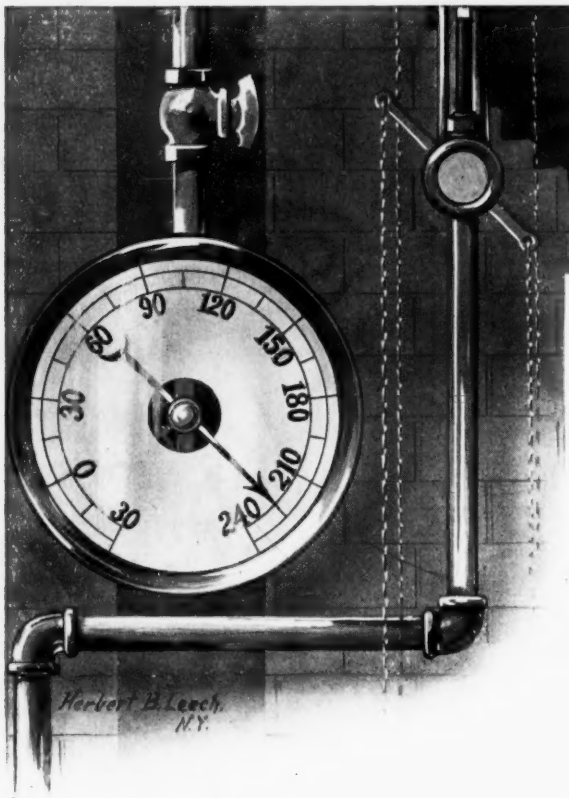
San Francisco Office and Warehouse—268 Market Street.



HIGH STEAM PRESSURE
does not affect

PALMETTO
PACKING

Because it contains no vegetable substance (such as rubber, cotton duck or flax) and long life is the result of its unusual lubrication. Braided, round and square (in 5 lb. boxes) for large stems.

Twist (on 1 lb. spools) for small stems.

Free working samples will prove why you should use Palmetto—Send for them.

GREENE, TWEED & CO.,
Sole Manufacturers
109 Duane St., New York.

THE BRISTOL COMPANY,
Manufacturers of
Recording Instruments

For Pressure, Temperature and Electricity

Bristol's Recording Thermometers
Especially Valuable for Feed Water of Steam Boilers.
SEND FOR NEW CATALOGUES.
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New York BRANCH OFFICES Chicago

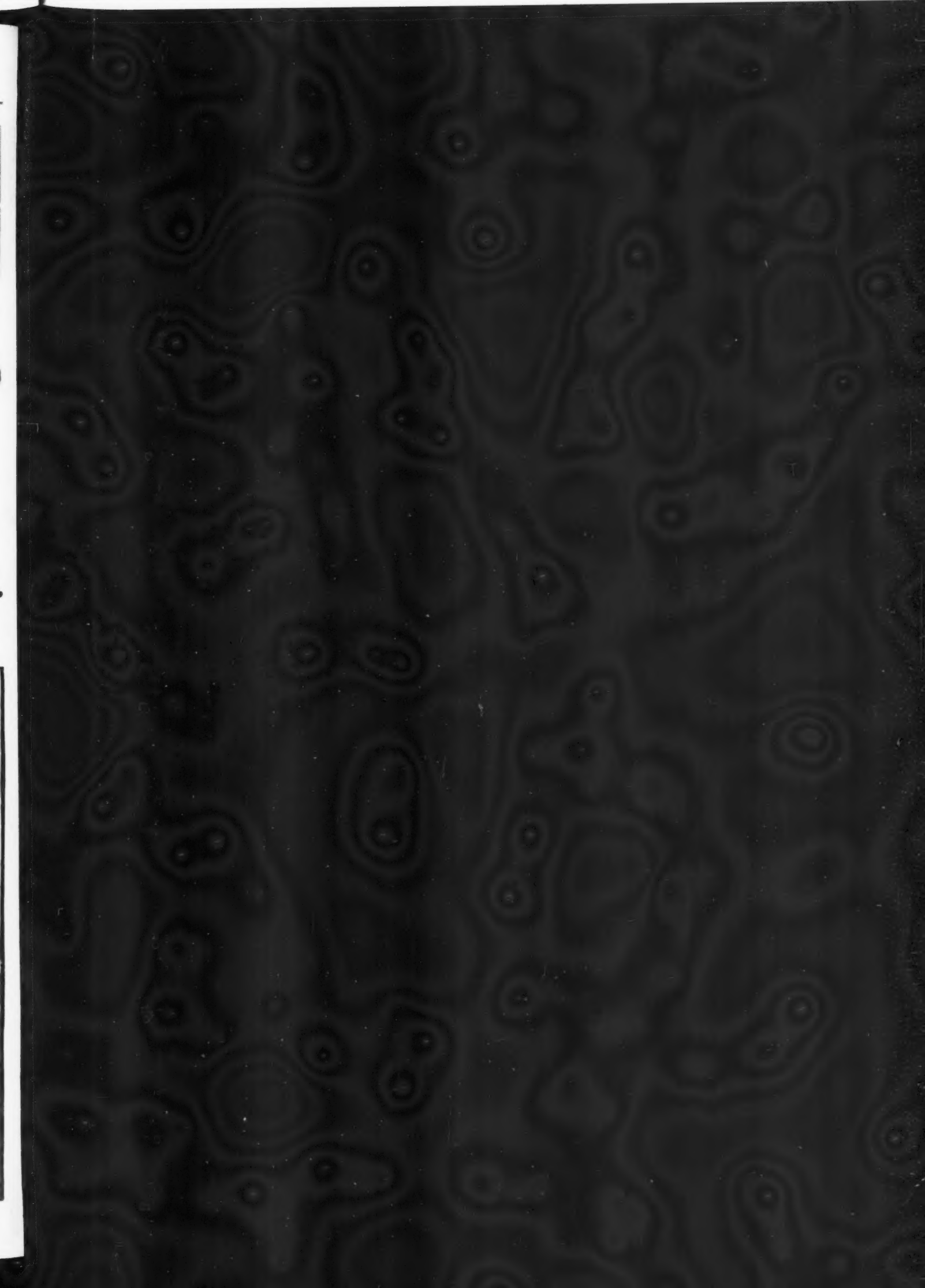
STARRETT
SPEED INDICATORS
OR REVOLUTION COUNTERS

No. 104.—This indicator may be run at the highest speed required without heating. The working parts are encased. Dial has two rows of figures, reading right or left as the shaft may run. Steel pointed spindle with rubber tips for both pointed and centered shafts. The (O) mark may be instantly set at starting point.

Price, Postpaid, $1.00

No. 107.—Has all the good points of the above, and in addition has a hard rubber handle for insulation when used on electrical machinery. It also automatically registers the number of revolutions up to 5,000, thus relieving the mind from keeping count.

Price, Postpaid, $3.00

Send for FREE Catalogue, No. 17-R, of Fine Tools.

The L. S. Starrett Co.
Athol, Mass., U. S. A.